Economic Appendix
Draft for Agency Technical Review
Post Authorization Change Report

Sacramento River Bank Protection Project
Sacramento River Basin, California

December 2014

US Army Corps of Engineers
Sacramento District

Department of Water Resources
State of California

Sacramento River Bank Protection Project

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1. PURPOSE

This report describes the assumptions, data, methodologies, and techniques used to perform the economic analysis as part of the Sacramento River Bank Protection Project (SRBPP) Post-Authorization Change Report (PACR). The results and conclusions of the analysis are also presented in this report.

The economic analysis was originally completed in 2011 for the primary purpose of determining benefit-to-cost ratios to be used for the U.S. Army Corps of Engineers' (USACE) annual program/project economic justification. The 2011 analysis and report were essentially carried forward to this PACR but updated for price level (benefits) in 2013; costs were also revised at that time. The results of the last update in 2013 indicated that eight sub-basins (Butte Basin, Natomas, Sacramento, Southport, Sutter Island, Yolo, West Sacramento, and Rio Oso) were economically feasible. The main purposes of this report, then, are to:

- Update damages and benefits for price level, focusing on the eight sub-basins that were determined to be economically feasible from the last update
- Incorporate revised costs into the economic analysis, focusing on the eight sub-basins that were determined to be economically feasible from the last update
- Update and verify the benefit-to-cost ratios of the eight sub-basins

This document reflects several updates that have occurred during the planning process leading up to the public release. While prior analyses encompassed the entire study area, the primary focus of the updates were those economic impact areas/sub-basins determined to be economically feasible. Therefore, the analysis/values shown in Sections 9-13 below, which cover all economic impact areas/sub-basins, were not updated for price level or discount rate; these values are based on an October 2012 price level and a 3.75% federal discount rate, which was the prevailing rate at the time of the initial update (2013). Section 13 of this report describes the eight economically feasible sub-basins that were determined to be economically feasible during a second update. Finally, Section 14 describes the seven sub-basins that were determined to be economically feasible during the latest update. The updated benefits and costs for the latest update are in October 2013 prices; a federal discount rate of 3.50% was used.

2. BACKGROUND

The SRBPP is a federal program which recognizes that bank erosion control and stabilization are necessary to ensure the integrity of the Sacramento River Flood Control Project (SRFCP), which includes approximately 1,300 miles of project levees that protect approximately 2.1 million acres of agricultural and urban land uses.

The SRBPP originally consisted of two phases. Phase I was initially authorized by the Flood Control Act of 1960 and consisted of approximately 430,000 feet of levee work; Phase I work has since been completed. Phase II was authorized by the River Basin Monetary Authorization Act of 1974 and consisted of approximately 405,000 feet of levee work; there is approximately 15,646 feet of levee work remaining under the 1974 authorization, but an additional 80,000 feet was authorized by the Water Resources Development Act (WRDA) of 2007 and added to the SRBPP's Phase II work. The economic analysis presented in this report addresses the economic feasibility of potential levee stabilization work authorized under the WRDA of 2007. The USACE Sacramento District identified 106 erosion sites for this analysis; these sites were selected through field observations originally conducted in the year 2007. The original 106 erosion sites used for the aforementioned 2011 economic analysis were also used for the PACR analysis.

For purposes of providing an idea of the geographic scope, Figure 1 on the following page is a map of the SRBPP study area and levees; Figure 2 below displays the 106 erosion sites.

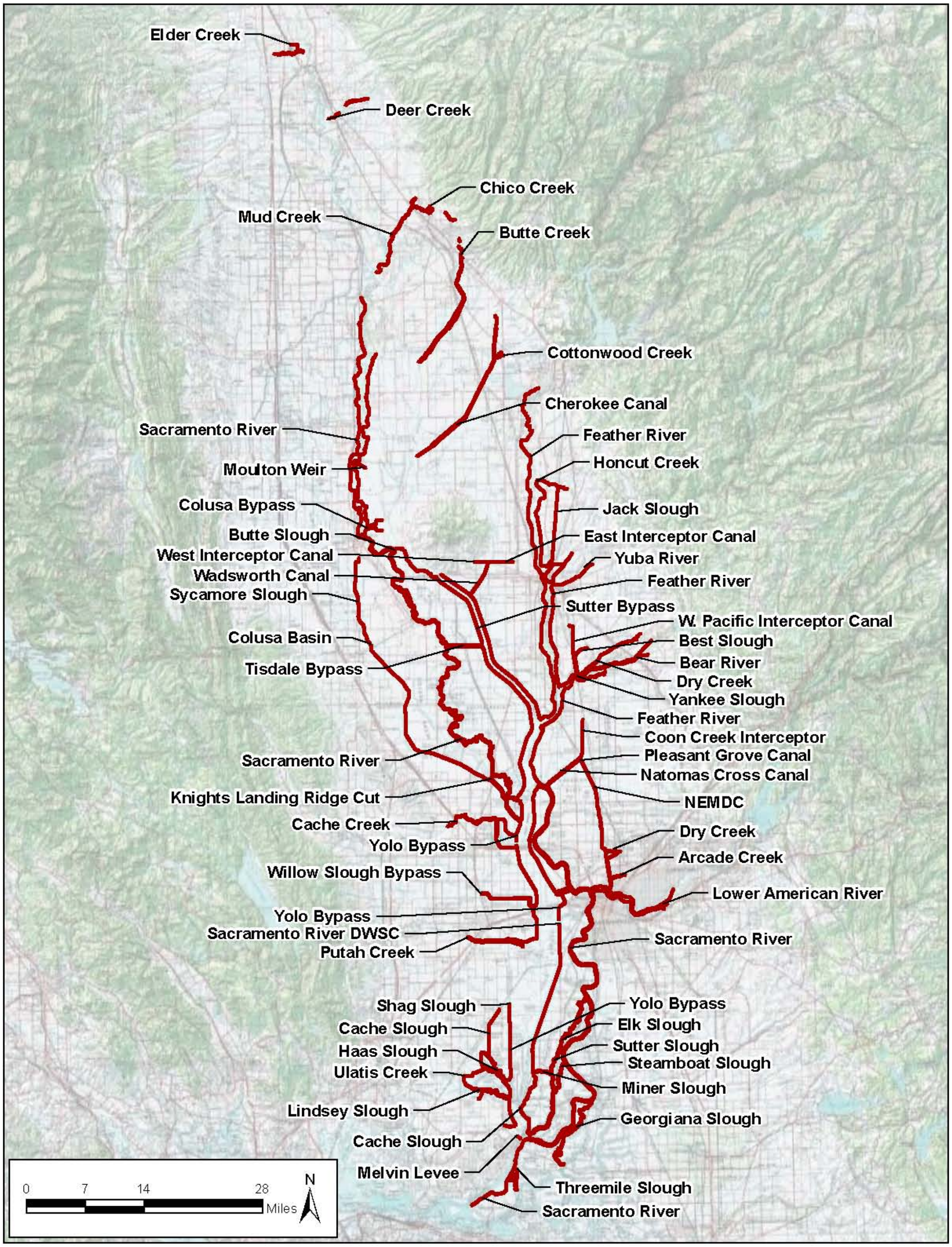

Figure 1: Geographic scope of SRBPP levees.

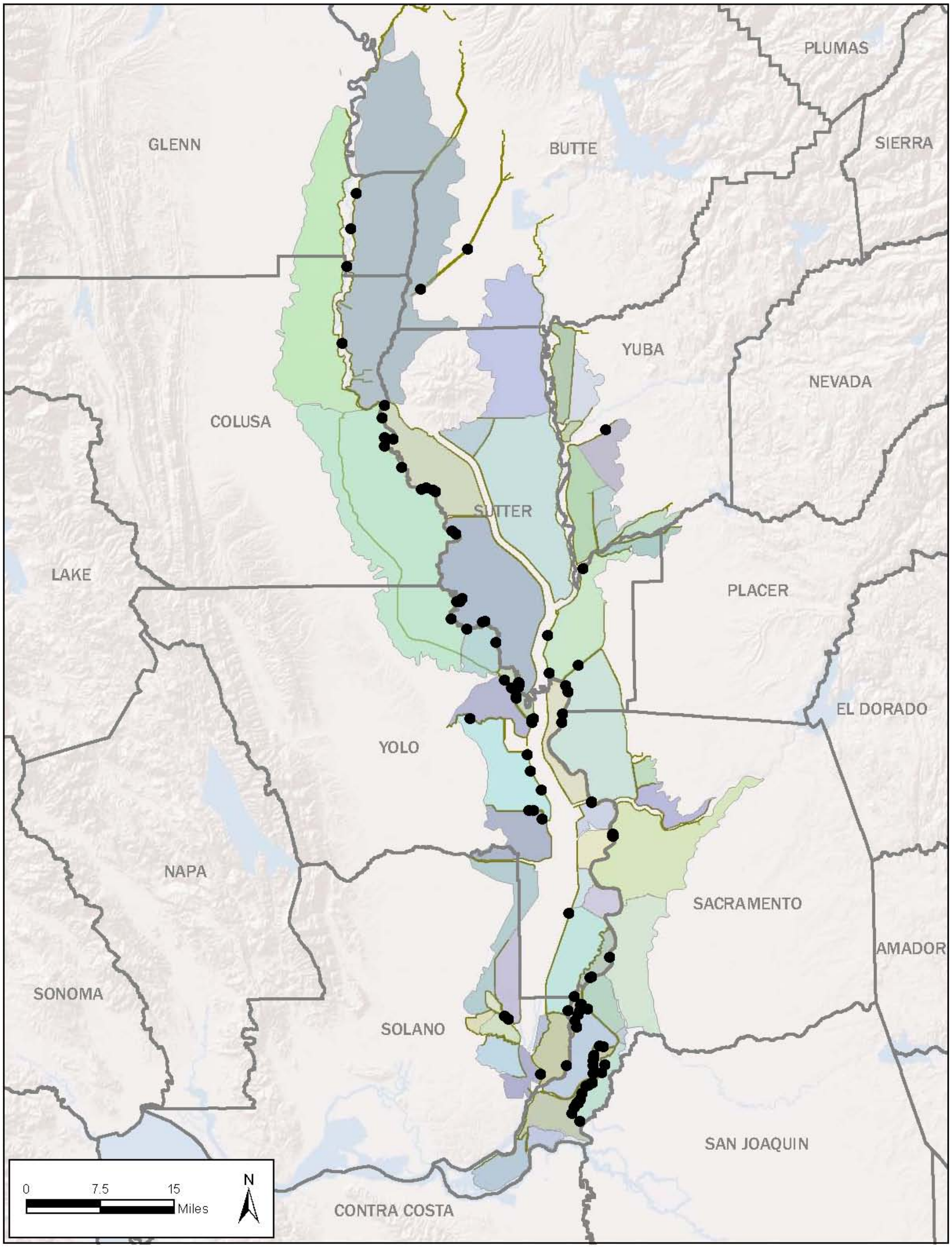

Figure 2: Geographic scope and approximate locations of 106 erosion sites.

3. PREVIOUS SRBPP ECONOMIC ANALYSES AND COMPLIANCE WITH CURRENT GUIDANCE

Previous economic analyses for the SRBPP were performed using methods that would not necessarily be relevant or sufficient under current USACE guidance. Some of the past analytical approaches used to economically justify the SRBPP include:

- Determining operation and maintenance (O&M) costs and computing benefits based on a reduction (or savings) in these costs once erosion work was completed
- Estimating benefits based on the reduction of potential inundation losses (damages prevented); damages were calculated based on the potential number of acres inundated throughout the system (assuming levee failures due to erosion) and applying gross losses per acre for rural and urban areas to the estimated number of acres
- Providing qualitative descriptions of the potential accomplishments of the SRBPP, which include protecting a large human population, protecting a significant amount of physical property, and protecting high-value agricultural acreage
- Extrapolating damages/benefits calculated by analyzing only small sections of levee repair and by assuming unusually high without-project damaging flood probabilities (annual exceedance probabilities or AEPs) normally associated with levees requiring immediate emergency repair; high AEPs are not necessarily applicable to the SRBPP levees

The economic analysis presented in this report was performed using current USACE guidance. Defined economic impact areas (rather than one large area as has been used in the past), a current economic inventory, a risk analysis approach (incorporating exceedance probability discharge curves with uncertainty, hydraulic floodplains, geotechnical fragility curves, and economic stage-damage curves), and clear, transparent descriptions of both the assumed without-project and with-project conditions were used in the analysis to estimate project benefits both as an entire system and incrementally by impact area/basin. These are discussed in more detail in the following sections of this report.

4. CONSISTENCY WITH REGULATIONS AND POLICIES

This economic analysis was performed in accordance with standards, procedures, and guidance of the USACE. The *Planning Guidance Notebook* (Engineering Regulation, ER 1105-2-100) serves as the primary source for evaluation methods for flood risk management (FRM) studies and was used as reference for this analysis. Additional guidance for risk analysis was obtained from Engineering Manual (EM) 1110-2-1619 (*Engineering and Design – Risk-Based Analysis for Flood Damage Reduction Studies*, August 1996) and ER 1105-2-101 (*Planning Risk-Based Analysis for Flood Damage Reduction Studies*, revised January 2006).

5. PRICE LEVEL, PERIOD OF ANALYSIS, AND DISCOUNT RATE

Monetary values presented in Sections 9-13 are in October 2012 prices (since the last update was performed in calendar year 2013). Costs and benefits of the various alternatives were amortized over a 50-year period of analysis using a federal discount rate of 3.75%, which was the prevailing rate at the time of the last update. The base year, or the year in which stabilization work of an erosion site is assumed to be completed, was assumed to be 2014. Costs used in the benefit-to-cost analysis include project costs, which were calculated by the Cost Engineering Section (SPK) and interest during construction (IDC), which were also calculated by the Cost Engineering Section (SPK).

Section 14 highlights the eight economically feasible sub-basins, which are the main focus of this current update and report. Updated benefits and costs are presented at October 2014 price levels and were calculated using the current federal discount rate of 3.50% and a 50-year period of analysis. The base year is assumed to be 2015.

6. DEFINITION OF ANNUAL EXCEEDANCE PROBABILITY (AEP)

The economic analysis relies heavily on assumed annual exceedance probability (AEP) information derived specifically for the SRBPP or for other on-going studies in the Sacramento District. The AEP is the probability that flooding will occur in any given year considering the full range of possible annual floods. Within the HEC-FDA model, AEPs are computed by integrating hydrologic/ hydraulic and geotechnical data in the form of exceedance probability-discharge-stage curves and geotechnical fragility curves/target top of levee stages.

7. SUMMARY OF MAJOR ASSUMPTIONS UNDERLYING THE ECONOMIC ANALYSIS

This major assumptions underlying and driving the economic analysis are summarized below:

- The target annual exceedance probability (AEP) information for the without-project condition was obtained from the contractor-developed report, *Annual Exceedance Probability of Failure and Sensitivity Analysis Due to Bank Erosion* (URS Corporation, February 2011). The primary purpose of this information is to estimate without-project damages and benefits for the SRBPP; the AEP information is not meant to serve as a detailed, authoritative engineering analysis of conditions at each erosion site. (More details on the AEP analysis and results can be found in the URS-developed report, which is attached as Enclosure 1 to this report.)

- The economic analysis assumed a without-project condition equivalent to Condition A as described in the URS report. Condition A describes the existing condition at the 106 erosion sites in 2010 assuming no flood event has occurred that would have caused the erosion sites to worsen. Existing project performance levels in terms of annual exceedance probabilities (AEP) presented in the contractor-provided report for Condition A were used to model the without-project condition in the economic model (HEC-FDA). Annual exceedance probability values presented in the URS report assume failure due to erosion only; other mechanisms of failure such as under seepage, through seepage, and stability were not accounted for in the AEP assessment.

- The URS report also lays out AEP information for several other conditions, all of which make different assumptions. In particular, Condition C is also a without-project condition, but unlike in Condition A, Condition C is a most likely future condition for the year 2025 and assumes that a flood event has occurred that would cause a particular erosion site to worsen. At most erosion sites, estimated AEP levels associated with Condition C are either 1) the same as those estimated for Condition A (at the same erosion site) or 2) are exceeded by or equal to the Condition A AEP estimate of another erosion site associated with the same economic impact area. For economic analysis purposes, then, existing without-project and most likely future without-project conditions were assumed to be Condition A in terms of hydrology, hydraulics, and geotechnical data inputs into the HEC-FDA. Using the AEP information from Condition A allows for a more conservative estimate of damages and benefits than using the AEP information from either Condition B or from Conditions A and C in combination. Using the lower AEP associated with Condition A translates into lower without-project expected annual damages (EAD) and therefore, of all the conditions presented in the URS report, has the lowest potential risk of overstating benefits.

- The AEPs associated with the with-project condition were assumed to be equal to the without-project AEPs developed for the 2002 Sacramento and San Joaquin Basins Comprehensive Study for those economic impact areas where more current HEC-FDA input data (exceedance probability-discharge and geotechnical fragility curves) are not available. In areas where there is more current data, these data (and corresponding AEP information) were used in the analysis. The idea behind this assumption is that once erosion sites within an impact area are fixed, the AEP associated with a particular impact area improves to the AEP estimated by either the (without-project) AEP of the Comprehensive Study or the AEP estimated by a study more current than the Comprehensive Study.

- The same hydrologic exceedance probability-discharge curves and hydraulic floodplains were used for the without-project and with-project conditions.

- The difference between the without-project and with-project expected damages is controlled by the difference in AEP between the two conditions, which in turn is driven by the difference in geotechnical fragility curves between the two conditions. For each impact area, the geotechnical fragility curves used to represent the SRBPP with-project condition were taken from either the Comprehensive Study without-project analysis or from a more current Corps analysis depending on the particular study area; these SRBPP “with-project” fragility curves were then adjusted in HEC-FDA in order to obtain the appropriate “without-project” AEP as outlined by Condition A in the URS report. This process is described in more detail in a subsequent section entitled, *Economic Model and Analytical Approaches/Techniques*.

- For each economic impact area, expected damage analysis were computed in HEC-FDA using data (exceedance probability-discharge curves, geotechnical fragility curves, and economic stage-damage curves) at the index point locations delineated either for the Comprehensive Study or another more current study and do not necessarily correspond to the exact erosion site location. Index points are used in HEC-FDA for damage aggregation purposes and for the purposes of characterizing risk (chance of flooding) in terms of AEP for an economic impact area.

- The construction period for fixing an erosion site was assumed to be one year. This assumption affects interest during construction (IDC) calculations.

- Benefit-to-cost ratios are based on the assumption that all known problems (erosion sites) within an impact area are fixed; the assumption that all known problems are fixed is based upon taking all precautions to ensure that the recommendations are comprehensive in nature.

8. ECONOMIC IMPACT AREAS

The economic impact areas used for this analysis follow closely those delineated for the 2002 Sacramento and San Joaquin River Basins Comprehensive Study primarily because much of the engineering data used in this economic analysis was developed for the Comprehensive Study. There were some minor adjustments made that combined certain Comprehensive Study impact areas into one area for the purposes of the SRBPP analysis. For example, in the Comprehensive Study, the Colusa Basin was separated into two areas; for this analysis, the Colusa Basin was considered one impact area. As another example, the Knights Landing area was delineated into two impact areas in the Comprehensive Study, but is considered as only one impact area for this analysis.

Table 1 below displays the economic impact areas (number from Comprehensive Study and geographic location), all of the waterways along which erosion sites have been identified (per impact area), and the number of erosion sites associated with each impact area. As mentioned previously, 106 erosion sites, each associated with one of 24 economic impact areas, have been identified for this analysis. Of the 106 erosion sites, 101 were included in the economic analysis.

Figure 3 displays all of the economic impact areas.

Table 1: Economic Impact Areas, Associated Waterways, and Number of Erosion Sites

Economic Impact Area (Number from Comprehensive Study)	Associated Waterways with Erosion Sites[1]	Number of Erosion Sites Identified
Butte Basin (5)	Sacramento River	4
Grimes (10)	Sacramento River	6
South Sutter (11/34)	Sacramento River	10
Knights Landing (13/14)	Knights Landing RC; Yolo Bypass; Sac River	8
Yolo (15)	Cache Creek; Knights Landing Ridge Cut	2
Woodland (16)	Yolo Bypass; Willow Slough	5
Davis (17)	Willow Slough	1
Linda (27)	Yuba River	1
Rio Oso (30)	Bear River; Natomas Cross Canal; Feather	4
North Sutter (32)	Sacramento River	6
Elkhorn (35)	Sacramento River	3
Natomas (36)	Sacramento River	1
Arden/Rio Linda (37)	American River	1
West Sacramento (38)	Sacramento River	2
Southport (39)	Sacramento River	2
Sacramento (40)	Sacramento River	3
Clarksburg (42)	Sutter Slough; Deep Water Ship Channel	3
Merritt Island (46)	Sacramento River	3
Sutter Island (49)	Steamboat Slough; Sutter Slough	4
Grand Island (50)	Steamboat Slough; Sacramento River	4
Tyler Island (53)	Georgiana Slough	17
Brannan Andrus Island (54)	Sacramento River	7
Ryer Island (55)	Steamboat Slough; Cache Slough	2
Hastings Tract (61)	Cache Slough	2

[1] Erosion sites on Cherokee Canal, Deer Creek, and Elder Creek were not analyzed due to insufficient data; in addition, these waterways protect impact areas that contain minimal economic consequences in terms of agricultural and urban damages.

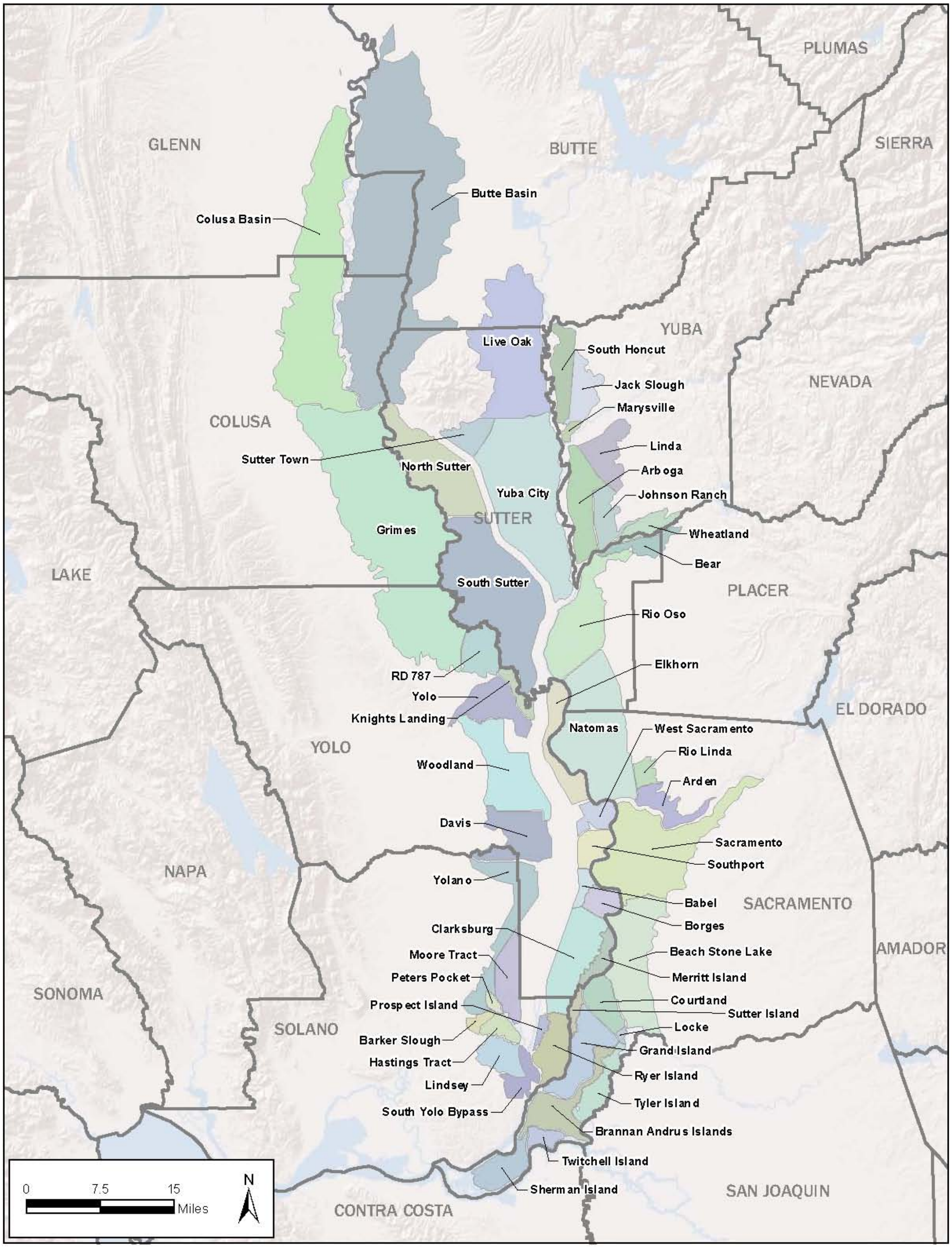

Figure 3: Map of economic impact areas.

9. DATA SOURCES AND DEVELOPMENT

The following sections describe the data sources and development used in the economic analysis.

9.1 Hydrologic, Hydraulic, and Geotechnical Data

For the majority of economic impact areas, the hydrologic/hydraulic/geotechnical HEC-FDA input data (exceedance probability-stage, floodplains, and fragility curves) were developed for the Comprehensive Study and used for the SRBPP analysis. For other impact areas, more current data was obtained from the appropriate Sacramento District studies and used in this analysis. Table 2 below shows the source of the HEC-FDA input data used for each of the 24 economic impact areas. Enclosure 2 to this report includes the HEC-FDA input data (exceedance probability-discharge-stage curves and geotechnical fragility curves) used for each impact area.

Table 2: Sources of Data – Exceedance Probability-Discharge-Stage Curves, Floodplains, and Fragility Curves

Economic Impact Area	Sources of Data					
	Exceedance Probability-Discharge-Stage Curves		Floodplain Depths		Fragility Curves	
	Without-Project	With-Project	Without-Project	With-Project	Without-Project	With-Project
27	2010 Yuba River GRR	2010 Yuba River GRR	2010 Yuba River GRR	2010 Yuba River GRR	Adjusted[2]	2010 Yuba River GRR
36	2010 Natomas PAC	2010 Natomas PAC	2010 Natomas PAC	2010 Natomas PAC	Adjusted[2]	2010 Natomas PAC
37	2008 ARCF GRR[1]	2008 ARCF GRR[1]	2002 Comp Study	2002 Comp Study	Adjusted[2]	2008 ARCF GRR[1]
38	2010 West Sac GRR	2010 West Sac GRR	2010 West Sac GRR	2010 West Sac GRR	Adjusted[2]	2010 West Sac GRR
39	2010 West Sac GRR	2010 West Sac GRR	2010 West Sac GRR	2010 West Sac GRR	Adjusted[2]	2010 West Sac GRR
40	2008 ARCF GRR[1]	2008 ARCF GRR[1]	2002 Comp Study	2002 Comp Study	Adjusted[2]	2008 ARCF GRR[1]
All others	2002 Comp Study	2002 Comp Study	2002 Comp Study	2002 Comp Study	Adjusted[2]	2002 Comp Study

[1]American River Common Features General Reevaluation Report (F3 Milestone)
[2]Without-project fragility curves were derived by adjusting the with-project fragility curves to target the appropriate contractor-developed AEP for Condition A as presented in Enclosure 1 of this report.

9.2 AEP Information for the Without-Project Condition

The AEP information for each erosion site and for various conditions was developed by consultants (URS). As mentioned previously, the AEP information for Condition A was used in this analysis to represent the without-project (no erosion stabilization work) condition for each site. Table 3 below displays the without-project AEP for each erosion site. More details regarding the development of the AEP information can be found in the contractor-developed report provided as Enclosure 1.

It also must be emphasized that the geotechnical engineering information (i.e., the without-project annual exceedance probability, or AEP, information) used in this economic analysis was developed specifically for the purpose of estimating damages and benefits of the programmatic SRBPP and to determine benefit-to-cost ratios for the USACE's annual economic analyses; the AEP information was not intended to provide an authoritative, detailed geotechnical engineering analysis of the conditions of the project levees.

Table 3: AEP Information for Condition A by Erosion Site

Annual Exceedance Probability (AEP) in %	Erosion Site
.5	Deep Water Ship Channel LM 5.0L, 5.01L; Sacramento River RM 35.3R
1	Knights Landing Ridge Cut (KLRC) LM 0.2R; Lower American River RM 7.3R; Sacramento River RM 35.4L, 78.3L; Willow Slough LM 2.2L, 0.6L; Yuba River LM 2.3L
2	Cherokee Canal LM 14.0L; KLRC LM 5.3L; Sacramento River RM 60.1L, 63.0R; Sutter Slough RM 24.7R; Yolo Bypass LM 2.0R
4	Cache Slough RM 15.9L, 22.8R; Cherokee Canal LM 21.9L; Deer Creek LM 2.4L; Elder Creek LM 3.0R, 4.1L; Feather River RM 0.6L, 5.0L; Georgiana Slough RM 2.5L, 3.6L, 4.0L, 4.3L, 4.5L, 4.6L, 6.1L, 6.4L, 6.6L, 6.8L, 8.3L; KLRC LM 3.0L, 3.1L, 4.2L; Natomas Cross Canal LM 3.0R; Sacramento River RM 21.5L, 22.5L, 22.7L, 23.2L, 23.3L, 24.8L, 25.2L, 31.6R, 38.5R, 56.5R, 56.6L, 56.7R, 58.4L, 62.9R, 74.4R, 75.3R, 77.7R, 86.3L, 86.5R, 86.9R, 92.8L, 95.8L, 96.2L, 101.3R, 103.4L, 104.0L, 104.5L, 116.0L, 116.5L, 122.0R, 122.3R, 123.3L, 123.7R, 127.9R, 131.8L, 132.9R, 133.0L, 133.8L, 136.6L, 138.1L, 163.0L, 168.3L, 172.0; Steamboat Slough RM 23.2L, 23.9R, 25.0L, 25.8R, 26.0L; Sutter Slough 26.5L; Willow Slough LM 6.9R; Yolo Bypass LM 0.1R, 2.5R, 2.6R, 3.8R
10	Georgiana Slough RM 0.3L, 1.7L, 9.3L; Steamboat Slough RM 18.8R
20	Bear River RM 0.8L; Elder Creek LM1.4L; Georgiana Slough RM 3.7a/b, 5.3L
50	Cache Creek LM 3.9L; Cache Slough RM 23.6R; Sacramento River RM 99.0L, 152.8L; Steamboat Slough 24.7R

9.3 Economic Inventory: Collection of Base Data and Valuations (Structures and Contents)

For each economic impact area, base geographic information system (GIS) inventories with parcel attribute data was obtained from Michael Baker consultants; this data is based on county assessor data. Building attribute data were used to determine land use and valuation of structure and contents. In those areas where existing data did not exist, field visits were taken to collect the base inventory data using standard USACE practices; for several impact areas, current inventories and valuations were taken from other on-going District studies and no fieldwork was required. The following section describes the data collection process in more detail.

Fieldwork was used to verify and collect land use and structure characteristics pertinent to the economic analysis. Field sheets containing the base inventory data were taken to the field along with aerial maps for identification. Characteristics observed in the field were recorded on the field sheets, including:

- The number of stories/floors in the building.
- The foundation height of a building, which was estimated by taking the difference the average ground elevation and the first floor of the structure.
- The specific building use (residential and non-residential occupancy types), including those shown in Table 4 below.
- The building class (a: primary characteristic- steel reinforced frame, b: reinforced concrete frame, c: masonry, d: wood frame, s: pre-fabricated metal frame), which corresponds to the classifications listed in the Marshall and Swift (M&S) Valuation Service handbook. Each of the five classifications corresponds to a grade of construction for use in the structure valuation.
- The construction type (e.g., excellent, very good, good, average, fair, low cost), which addresses the quality of construction and which also used as input into the structure valuation.
- The structure condition (e.g., new, excellent, very good, good, fair, poor), which is a subjective measure of the remaining life of the structure. (This is not a measure of the actual age as many older structures may have been restored and may have had improvements made to extend its remaining life.) The estimated percentage of remaining value (percent good factor) was recorded to account for depreciation, which is also an input into the structure valuation. Table 5 below lists descriptions of the conditions used and the associated percent good factors used in the structure valuations.

Table 4: Occupancy Types

Occupancy Type	Description
Single-family residential (SFR)	Detached SFR, half-plexes, duplexes, townhomes
Multi-family residential (MFR)	Apartments, townhomes, attached multiple units
Mobile homes (MH)	Mobile homes and parks
Commercial office buildings	Office buildings
Retail	Typical retail stores
Food	Retail stores that sell perishable food items
Restaurants	Restaurants and fast food establishments
Medical	Medical, dental, hospitals, care facilities, veterinary
Shopping centers	Large shopping centers, box stores, shopping malls
Service	Auto repair, service, and maintenance shops
Warehouses	Warehouses, storage, transportation centers
Light industrial	Small tool shops, light manufacturing
Heavy industrial	Heavy manufacturing, large plants
Government	Gov't buildings, county-, city-, state- and federally- owned offices
Schools	Elem., middle, and high schools; colleges; day care/pre-school fac.
Churches	Churches
Recreation	Recreation assembly, clubs, theaters
Farm	Non-res outbuildings, sheds; family farm res.; lt. production fac.

Table 5: Condition Classes and Percent Good Factors

Condition	Percent Good Factor
New	100%
Excellent	95%
Very Good	90% to 95%
Good	80% to 90%
Fair	70% to 80%
Poor	50% to 70%
Other (abandoned, condemned)	0%

Table 6 below lists the number of structures by impact area and broken down by major damage category (residential, commercial, industrial, public, and farm).

Table 6: Number of Structures by Economic Impact Area and Damage Category

Economic Impact Area	Number of Structures				
	COM	**IND**	**RES**	**PUB**	**TOTAL**
Butte Basin (5)	--	--	131	--	131
Grimes (10)	--	--	49	--	49
South Sutter (11/34)	--	--	17	--	17
Knights Landing (13/14)	11	4	271	5	291
Yolo (15)	--	--	1	--	1
Woodland (16)	2	6	--	--	8
Davis (17)	3	2	88	1	94
Linda (27)	4	5	1,056	6	1,071
Rio Oso (30)	--	--	64	--	64
North Sutter (32)	--	--	131	--	131
Elkhorn (35)	--	--	--	--	--
Natomas (36)	303	156	22,265	85	22,809
Arden/Rio Linda (37)	737	216	15,247	141	16,341
West Sacramento (38)					
Southport (39)	485	484	17,419	99	18,487
Sacramento (40)	3,510	1,206	128,015	918	133,649
Clarksburg (42)	10	7	114	6	137
Merritt Island (46)	45	9	145	8	207
Sutter Island (49)	--	1	5	--	6
Grand Island (50)	--	--	--	--	--
Tyler Island (53)	--	--	2	--	2
Brannan Andrus (54)	80	11	3	80	174
Ryer Island (55)	--	1	3	--	4
Hastings Tract (61)	--	--	--	--	--
TOTAL	**5,190**	**2,108**	**185,026**	**1,349**	**193,673**

The total value of damageable property (structures and contents) for the 24 impact areas included in this analysis is approximately $100 billion. Table 7 below displays the total value of damageable property, also by impact area, and broken out by structure value and content value.

Table 7: Total Value of Damageable Property – Structures & Contents (October 2012 Price Level, in $1,000s)

Economic Impact Area	Value of Damageable Property		
	Structures	**Contents**	**Total**
Butte Basin (5)	12,210	6,104	18,314
Grimes (10)	4,948	2,475	7,423
South Sutter (11/34)	3,749	1,875	5,624
Knights Landing (13/14)	44,923	28,825	73,748
Yolo (15)	19	9	28
Woodland (16)	53,970	47,211	101,181
Davis (17)	50,983	26,522	77,505
Linda (27)	114,585	120,044	234,629
Rio Oso (30)	6,210	3,105	9,315
North Sutter (32)	12,209	6,104	18,313
Elkhorn (35)	0	0	0
Natomas (36)	5,876,118	2,996,706	8,872,824
Arden/Rio Linda (37)	10,083,891	5,114,688	15,198,579
West Sacramento (38) Southport (39)	2,945,844	2,034,480	4,980,324
Sacramento (40)	47,083,117	22,589,068	69,672,185
Clarksburg (42)	21,584	5,151	26,735
Merritt Island (46)	25,310	18,522	43,832
Sutter Island (49)	708	404	1,112
Grand Island (50)	0	0	0
Tyler Island (53)	255	128	383
Brannan Andrus Is. (54)	38,987	33,340	72,327
Ryer Island (55)	443	269	712
Hastings Tract (61)	0	0	0
TOTAL	**66,380,063**	**33,035,030**	**99,415,093**

All structures were valued based upon a function of square footage, estimated cost per square foot (from the Marshall & Swift Valuation Handbook), and an estimated percent good factor. Values per square foot were based on occupancy type, building class, and construction type as outlined in Marshall and Swift Valuation Service handbook. Structure values are based on the concept of depreciated replacement value, rather than market value or assessed value. Generally speaking, flooding causes damages primarily to physical improvements to the land, such as structures and contents, and does not necessarily cause damage to the land. Replacement cost of the structure and its contents less depreciation, therefore, is used to determine structure/content values, which then serves as the basis for the NED damage/benefit analysis. Median square footage information and median depreciated replacement values can be found in Enclosure 3.

Non-residential content values were based on the results of an expert elicitation that was conducted for the American River Common Features General Reevaluation Report (GRR). An expert elicitation was performed to develop content values and content depth-percent damage curves for specific occupancy types. The results of that expert elicitation were used for the 2009 American River GRR as well as for this study. In total, there were 22 different occupancy types with values ranging from $22 to $235 per square foot with uncertainty.

For SFR structures, depth-percent damage curves developed by the USACE Institute for Water Resources (IWR) and presented in Economic Guidance Memorandum (EGM) 04-01, were used. Since the percentage damages in these generic depth-percent damage curves were developed as a function of structure value, it was unnecessary to explicitly derive content values for input into the HEC-FDA model; the model computes content damages by applying the percentages in the content-percent damage curves to structure values. For reporting purposes and to estimate content value for residential structures, a content-to-structure value ratio of 50% was used, which is consistent with the ratio used in other District studies.

9.4 Depth-Percent Damage Curves

The depth of flooding is the primary factor in determining potential damages to structures, contents, and automobiles. Damages to structures and contents were determined based on depth of flooding relative to the structure's first floor elevation. To compute these damages, depth damage curves were used. These curves assign loss as a percentage of value for each structure. The deeper the relative depth, the greater the percentage of value damaged. The sources of the functions were different depending on land use. Depth-percent damage functions were used in the HEC-FDA model to estimate the percent of value lost for the various occupancy types listed in Table 4 above.

Residential depth-damage curves (structures and contents) were taken from Economic Guidance Memorandum (EGM) 04-01, *Generic Depth-Damage Relationships for Residential Structures,* for use on both single-family and multi-family residential structures. Structures were identified as 1-story, 2-story, or split-level. Mobile home curves were taken from the May 1997 Final Report, *Depth Damage Relationships in Support of Morganza to the Gulf, Louisiana Feasibility Study*. Non-residential curves (structures) were based on the same 1997 Morganza study (USACE New Orleans District) and were used for this analysis.

Depth-percent damage functions for automobiles were based on averages from curves developed by the Institute for Water Resources (IWR) and provided in EGM 09-04, *Generic Depth-Damage Relationships for Vehicles*.

In 2007, non-residential content depth-percent damage curves were developed based on the previously-mentioned expert elicitation for various occupancy types; these curves were developed specifically for building types in the Sacramento Metropolitan area and were applied to this analysis.

The complete set of depth- percent damage functions with their corresponding uncertainties can be found in Enclosure 3.

9.5 Agricultural Crop Acreages

Agricultural acreages for each economic impact area were obtained from the Sacramento District's Geographic Information Systems (GIS) Section. Agricultural crop acreages formed the basis for the agricultural damage analysis. Table 8 below displays the number of agricultural acres in each economic impact area. Table 9 below displays by impact area the single-event agricultural damages for five annual chance events (ACE): 10-, 50-, 100-, 200-, and 500-year. These ACE damages were directly entered into the HEC-FDA model as stage-damage curves in order to compute expected agricultural damages and benefits.

Table 8: Total Number of Agricultural Acres by Economic Impact Area

Economic Impact Area	Acreage Per Annual Chance Event (ACE)				
	10-Year	50-Year	100-Year	200-Year	500-Year
Butte Basin (5)	108,117	116,667	118,013	121,562	126,904
Grimes (10)	0	84,194	88,128	98,696	111,613
South Sutter (11/34)	0	54,397	54,658	55,263	63,742
K. Landing (13/14)	0	3,348	3,348	3,348	3,348
Yolo (15)	0	5,432	5,433	5,434	5,916
Woodland (16)	0	3,423	5,075	5,760	10,777
Davis (17)	0	0	0	0	0
Linda (27)	0	0	6,757	7,527	9,020
Rio Oso (30)	0	0	0	26,638	27,020
North Sutter (32)	0	0	31,421	31,445	31,507
Elkhorn (35)	0	11,881	11,923	11,923	11,923
Natomas (36)	0	0	0	39,417	41,014
Arden/Rio Linda (37)	0	0	0	0	0
West Sac (38)	0	0	0	456	564
Southport (39)	0	0	0	2,851	3,267
Sacramento (40)	0	0	0	1,947	2,425
Clarksburg (42)	0	12,028	20,465	20,476	22,375
Merritt Island (46)	0	4,577	4,595	4,638	4,639
Sutter Island (49)	0	2,241	2,241	2,241	2,241
Grand Island (50)	0	15,681	15,681	15,681	15,681
Tyler Island (53)	0	8,680	8,685	8,690	8,695
Brannan Andrus (54)	0	13,346	13,348	13,348	13,354
Ryer Island (55)	0	10,974	11,278	11,278	11,278
Hastings Tract (61)	0	3,411	3,414	3,414	3,419
TOTAL	**108,117**	**350,280**	**404,463**	**492,033**	**530,722**

Table 9: Agricultural Damages by Event and Economic Impact Area (October 2012 Price Level, in $1,000s)

Economic Impact Area	Damage Consequences Per Annual Chance Event (ACE)				
	10-Year	50-Year	100-Year	200-Year	500-Year
Butte Basin (5)	99,814	129,399	131,721	152,254	180,381
Grimes (10)	0	65,734	70,324	84,184	94,144
South Sutter (11/34)	0	62,135	62,546	63,153	77,481
K. Landing (13/14)	0	5,851	5,851	5,851	5,851
Yolo (15)	0	4,224	4,224	4,508	4,909
Woodland (16)	0	1,876	2,753	3,118	5,429
Davis (17)	0	0	0	0	0
Linda (27)	0	0	8,353	8,748	9,576
Rio Oso (30)	0	0	0	48,300	49,114
North Sutter (32)	0	0	52,511	52,558	52,606
Elkhorn (35)	0	39,495	39,674	39,674	39,674
Natomas (36)	0	0	0	17,964	19,231
Arden/Rio Linda (37)	0	0	0	0	0
West Sac (38)	0	0	0	65	78
Southport (39)	0	0	0	1,289	1,520
Sacramento (40)	0	0	0	451	513
Clarksburg (42)	0	6,638	10,911	1,097	11,886
Merritt Island (46)	0	1,641	5,581	5,616	5,616
Sutter Island (49)	0	11,578	11,578	11,578	11,578
Grand Island (50)	0	28,609	28,609	28,609	28,639
Tyler Island (53)	0	7,245	7,245	7,248	7,248
Brannan Andrus (54)	0	12,440	12,440	12,440	12,460
Ryer Island (55)	0	11,060	11,100	11,100	11,100
Hastings Tract (61)	0	1,938	1,938	1,938	1,939
TOTAL	**99,814**	**389,861**	**467,358**	**571,606**	**630,971**

Note: The damages displayed in the table represent damages from a specific annual chance event (e.g., 10% ACE, 25% ACE, 50% ACE, etc.) and floodplain should that flood event/floodplain occur. These damages/frequencies do not reflect the chance of levee failure.

9.6 Economic Uncertainties

Uncertainties in key economic variables were considered. Key economic variables, or those which may have a significant impact on expected damages and benefits, include structure/content values, foundation heights/first floor elevations, and percent damages at specific depths of flooding.

Table 10 below lists the uncertainty used for structure and content values. These were taken from other District studies, including the *Natomas Post-Authorization Change Interim Reevaluation Report* (October 2010) and the *Folsom Dam Modification and Folsom Dam Raise Projects, Economic Reevaluation Report* (Feb 2008).

Table 10: Uncertainty in Structure and Content Values

OCCUPANCTY TYPE	UNCERTAINTY IN VALUE (INPUT TO HEC-FDA)	
	Structures (SD/Mean in Percent)	Contents (SD/Mean in Percent)
Residential (SFR & MFR)	17	--
Mobile Homes	14	--
Office 2-Story	15	14
Office 1-Story	15	16
Retail	13	18
Retail-Furniture	13	20
Auto Dealerships	12	16
Hotel	11	3
Food Stores	11	27
Restaurants	15	3
Restaurants-Fast Food	12	13
Medical	12	46
Shopping Centers	10	23
Large Grocery Stores	11	4
Service (Auto)	15	4
Warehouse	15	31
Light Ind.	16	19
Heavy Ind.	13	31
Government	14	16
Schools	12	33
Religious	12	40
Recreation	13	13
Automobiles	15	N/A

Uncertainty in first floor elevation was assumed to be 0.5 foot; uncertainty in percent damages at specific depths of flooding is presented in Enclosure 3, *Depth-Percent Damage Curves*.

9.7 Project Costs

Project costs for recommended measures/plans at each erosion site were developed by the Sacramento District's Cost Engineering Section. Interest during construction (IDC) was calculated by the District's Economics & Risk Analysis Section. Costs were compiled by basin and used in the economic net benefit and benefit-to-cost analyses. Tables 11 and 12 display the total project costs, the costs of interest during construction (IDC), total investment costs, and average annual costs by impact area (basin) and by groups of basins delineated by predominant land use – urban, agricultural, and mixed. A breakdown of the cost estimates by impact area can be found in Enclosure 4 to this report.

Table 11: Total Project Costs, Interest During Construction, Total Investment Costs, & Average Annual Costs (October 2012 Price Level, 3.75% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Impact Area (Basin)	Total Project Costs	Interest During Construction (IDC)	Total Investment Costs	Average Annual Costs
Butte Basin (5)	9,797	100	9,897	441
Grimes (10)	12,856	291	13,147	586
South Sutter (11/34)	61,696	1,507	63,203	2,818
Knights Landing (13/14)	10,131	480	10,611	473
Yolo (15)	2,266	39	2,305	103
Woodland (16)	5,067	54	5,121	229
Davis (17)	522	7	529	23
Linda (27)	3,034	40	3,074	137
Rio Oso (30)	6,991	69	7,060	314
North Sutter (32)	14,395	146	14,541	649
Elkhorn (35)	7,765	79	7,844	349
Natomas (36)	2,660	27	2,687	120
Arden/Rio Linda (37)	N/A	N/A	N/A	N/A
West Sacramento (38)	1,567	65	1,632	73
Southport (39)	9,821	95	9,916	443
Sacramento (40)	7,429	75	7,504	335
Clarksburg (42)	10,287	107	10,394	463
Merritt Island (46)	8,291	226	8,517	380
Sutter Island (49)	13,360	400	13,760	613
Grand Island (50)	12,166	124	12,290	548
Tyler Island (53)	127,705	6,083	133,788	5,963
Brannan Andrus Island (54)	21,471	222	21,693	967
Ryer Island (55)	7,754	84	7,838	349
Hastings Tract (61)	3,599	38	3,637	163
TOTAL	**360,630**	**10,358**	**370,988**	**16,539**

Table 12: Total Project Costs, IDC, Total Investment Costs, & Average Annual Costs by Analysis Group (October 2012 Price Level, 3.75% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Analysis Group Based on Predominant Land Use	Total Project Costs	Interest During Construction (IDC)	Total Investment Costs	Average Annual Costs
Agricultural	297,256	9,117	306,373	13,657
Urban	40,231	843	41,074	1,833
Mixed[1]	23,143	398	23,541	1,049
Total	**360,630**	**10,358**	**370,988**	**16,539**

[1]Mixed refers to those areas that cannot be characterized as either predominantly urban or agricultural.

10. ECONOMIC MODEL AND ANALYTICAL APPROACHES/TECHNIQUES

The following sections describe the economic model, analytical approaches, and data application techniques used to perform the economic analysis.

10.1 Economic Model: HEC-FDA

The economic model used to perform this economic analysis/update is the Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) model developed by the USACE Hydrologic Engineering Center (HEC) in Davis, California. This model was used to compute economic stage-damage curves with uncertainty as well as expected annual damages (EAD) and benefits (EAB) by integrating hydrologic, hydraulic, geotechnical, and economic data. HEC-FDA v1.2.4 and v1.3, which is a version modified specifically for the District for the 2008 Folsom Dam Modification and Folsom Dam Raise economic analysis in order to use the inflow-outflow functionality within the software. (The newer versions of HEC-FDA currently have this functionality.) The economic analysis completed in 2011 for budget purposes relied heavily on existing data and models; these same models were carried forward to this PACR.

10.2 Index Point Locations

This economic analysis was performed using the HEC-FDA model, which requires the input of engineering data at index point locations along a levee reach and tied to a particular economic impact area. These index points are used to aggregate damages and benefits within an impact area in HEC-FDA. For most impact areas delineated for the SRBPP, representative index point locations (and corresponding data) were taken from the Comprehensive Study analysis; for other areas, representative index point locations (and corresponding data) were taken from more current District studies. Table 13 below displays the index point locations used for this economic analysis.

Table 13: Index Point Locations by Impact Area

Economic Impact Area	Index Point Location Used in HEC-FDA Analysis
Butte Basin (5)	Sacramento River RM 183.50; TOL/TOB[1] = 112.86
Grimes (10)	Sacramento River RM 119.75; TOL/TOB = 55.51
South Sutter (11/34)	Sacramento River RM 92.00; TOL/TOB = 42.76
Knights Landing (13/14)	Sacramento River RM 90.00; TOL/TOB = 44.43
Yolo (15)	KLRC LM 3.02; TOL/TOB = 38.86
Woodland (16)	Yolo Bypass LM 48.84; TOL/TOB = 32.78
Davis (17)	Putah Creek; TOL/TOB = 46.23
Linda (27)	Yuba River LM 5.7; TOL/TOB = 94.2
Rio Oso (30)	Feather River RM 7.17; TOL/TOB = 52.5
North Sutter (32)	Sutter Bypass LM 88.60; TOL/TOB = 58.6
Elkhorn (35)	Sacramento River RM 76.75; TOL/TOB = 40.12
Natomas (36)	Sacramento River RM 79.0; TOL/TOB = 44.40
Arden/Rio Linda (37)	American River RM 11.33; TOL/TOB = 58.60
West Sacramento (38)	Sacramento River RM 59.99; TOL/TOP = 40.00
Southport (39)	Sacramento River RM 52.75; TOL/TOB = 39.00
Sacramento (40)	Sacramento River RM 51.00; TOL/TOB = 31.50
Clarksburg (42)	Sutter Slough RM 25.23; TOL/TOB = 22.86
Merritt Island (46)	Sacramento River RM 41.00; TOL/TOB = 26.21
Sutter Island (49)	Sutter Slough RM 23.73; TOL/TOB = 25.2
Grand Island (50)	Sacramento River RM 14.75; TOL/TOB = 22.85
Tyler Island (53)	Georgiana Slough RM 0.25; TOL/TOB = 10.53
Brannan Andrus Is. (54)	Georgiana Slough RM 0.75; TOL/TOB = 10.89
Ryer Island (55)	Sutter Slough RM 22.23; TOL/TOB = 25.35
Hastings Tract (61)	Cache Slough RM 21.0; TOL/TOB = 17.7

[1]TOL/TOB is "top of levee/top of bank."

10.3 Application of Hydrologic, Hydraulic and Geotechnical Engineering Data in HEC-FDA

The HEC-FDA engineering input data was developed by the District's Hydrologic, Hydraulic, and Geotechnical engineers for the 2002 Comprehensive Study and, for most of the impact areas, used in this analysis. In most impact areas, graphical exceedance probability-stage curves were entered into HEC-FDA along with an equivalent record length, which is used in HEC-FDA to estimate uncertainty in in-channel stage. Geotechnical fragility curves (without-project) for each impact area, which were also developed specifically for the Comprehensive Study, were used to represent the with-project condition – or the condition that is trying to be re-attained through the erosion stabilization work. Hydraulic floodplains were also developed for the Comprehensive Study and applied to this analysis (for most of the impact areas); floodplains were developed for the 10%, 2%, 1%, .5%, and .2% annual chance events.

10.4 Application of Floodplain Data within HEC-FDA Model

Comprehensive Study floodplains for the 10%, 2%, 1%, .5%, and .2% annual chance events (ACE) were provided by the District's GIS section as a GIS database of flood depths at each parcel/structure for each event. Flood depths were provided for the entire study area. The District's Economics and Risk Analysis Section then formatted the flood depth data in order to be able to import the data into HEC-FDA, which requires a specific format (HEC-RAS – River Analysis System profile format).

Instead of using river station numbers like in a typical HEC-RAS water surface profile (WSP), assignment of water surface elevations by ACE event were completed using grid cell numbers; the grid cell assignments represent actual floodplain water surface elevations by ACE event rather than in-channel water surface elevations. Once the formatted flood plain data were imported into HEC-FDA, a row was inserted at the top of the WSP which included the in-channel stages associated with the index point (for a particular impact area). This step allowed for the linkage between the 2-dimensional floodplain data and the in-channel stages within HEC-FDA. Importing formatted floodplain data and assigning water surface elevations to grid cells eliminated the need for creating interior-exterior relationships, which is another way to link exterior (river) stages to interior (floodplain) stages within HEC-FDA.

10.5 Computing Economic Stage-Damage Curves in HEC-FDA

Since structures and depths of flooding (water surface elevations) in the WSPs are linked by grid cell number, this technique allowed for the computation of stage-damage curves within HEC-FDA and eliminated the need to use other models (e.g., @Risk) to compute stage-damage curves. Once computed, stages in the stage-damage curves are scaled by HEC-FDA using the in-channel (exterior) stages at the index point (first row of data inserted into WSP). The index point, then, links the floodplain data (via stage-damage curves) to the channel hydrologic, hydraulic, and geotechnical engineering data in the HEC-FDA model.

10.6 Target AEPs to Compute Without-Project Damages and With-Project Residual Damages

This economic analysis requires the establishment of a without-project condition and a target with-project condition in order to be able to estimate "pre-project" damages and "post-project" residual damages, and therefore be able to measure outputs (benefits) of a project. The AEP information from the Comprehensive Study was used to establish the target with-project condition for most of the impact areas; the AEP information from the URS report was used to establish the without-project (pre-erosion repair) condition for all of the impact areas. For those impact areas where there is an on-going District study with more current data, AEP information from these studies were used in place of the Comprehensive Study information.

It should be emphasized that the intent of the contractor-developed AEP information was to provide information as input into this economic analysis, and not to provide a detailed assessment of the project levee conditions. (The contractor-developed AEP information is not meant to be an authoritative analysis of the current geotechnical conditions of the project levees. More detailed geotechnical analyses may be performed in the future.) The intent of this economic analysis is to reasonably estimate benefits of the SRBPP using the available data and information.

10.7 Target AEPs and Erosion Sites

"More critical" and "less critical" erosion sites within an impact area were identified based on information provided in the URS report. The AEPs associated with the erosion sites within an impact area were compared to one another. In all cases, an erosion site(s) within an impact area could be identified as having a higher AEP value than the remainder of the erosion sites (for that impact area); these sites were considered the "more critical" sites within the impact area and the AEPs associated with these sites represented the without-project condition (see next section). The "less critical" erosion sites were the remaining sites having a lower AEP value than the "more critical" sites. Initially, the AEP values associated with these sites were used to represent a first with-project condition; ultimately, however, these intermediate with-project conditions were not used in the economic analysis. Instead, the maximum attainable AEP for a particular impact area was represented by the AEP from either the Comprehensive Study analysis or from a District study having a more current analysis. This methodology reflects that even though erosion sites can be repaired to high level of performance, the risk to the impact area may be limited by the performance for other potential failure modes, (e.g.) under seepage, through seepage, instability). The AEP from the Comprehensive Study analysis (or from a District study having done current analysis includes consideration of those other potential failure modes, and thus represents the maximum attainable AEP for the impact area.

It should be noted that the terms "more critical" and "less critical" are not intended to imply site prioritization or an order of fixes. These terms were used within the context of the economic analysis to compare the magnitude of AEP values of sites within an impact area and to point out that the severity of erosion sites within an impact area, in terms of AEP, are not equal.

10.8 Adjusting Geotechnical Fragility Curves to Achieve Target AEPs and Estimate Benefits

The target without-project AEPs (Condition A from the URS report) were achieved by adjusting the "with-project" geotechnical fragility curves, which were actually represented by the without-project fragility curves from either the Comprehensive Study or another more current District Study. The fragility curves were adjusted in a methodical manner by first taking the same stages used in the "with-project" fragility curves, changing the probabilities of failure (starting from the lower stages), and then computing AEP in HEC-FDA. Although this adjustment technique was methodical, the process is one that can be characterized as inherently trial and error as each step of the adjustment process was repeated until the target without-project AEP (and first with-project condition AEP) was achieved in HEC-FDA. Enclosure 2 shows the geotechnical fragility curves (per impact area) used to represent the two states:

- Without-project condition: no erosion sites are fixed; this is the highest AEP identified in the URS report (Condition A) for an erosion site(s) of all the erosion sites (per impact area); this is the condition that exists due to some flow event causing an erosion issue.

- With-project condition: assumes the AEP using the information from either the Comprehensive Study or another more current District study; it is assumed that this condition represents the maximum attainable performance level for a particular impact area; this with-project condition is the state that exists prior to any erosion issue and to which an erosion repair is trying to re-attain; benefits are capped by this AEP value.

Table 14 below shows the target AEP values for each condition and by impact area.

It is important to note that for many reaches, the assumption regarding the maximum attainable AEP value as listed in Table 14 is greater (lower performing) than the without-project AEP estimate from the aforementioned URS report (Section 10.7), which appears to imply that the levee performance in these areas gets worse with repairs to the erosions site. This is not the case, however. For these reaches these values reflect that there are worse performance conditions for other potential failure modes, and that the AEP for the impact area is not governed by the erosion performance. This is unrealistic and not expected to occur, but is mainly an effect of using data from different sources that were developed using different methods. That is, whether or not the erosion is repaired, the AEP remains as characterized by the Comprehensive Study analysis (or more current District study analyses). In impact areas where this occurred, no benefits were claimed for that particular basin/impact area. However, in future studies when more current data/information becomes available which would allow for a more accurate measurement of pre-repair and post-repair performance, the estimate of benefits for these impact areas will be revised. In other words, the risk assessment methodology will be revised for the Sacramento River Bank Protection Project GRR and applied to future SRBPP updates, with a focus on revised geotechnical fragility curves.

Table 14: Annual Exceedance Probability (AEP) Values by Impact Area and State (Condition)

Economic Impact Area	AEP Value: Without-Project Condition[1]	AEP Value: Maximum Attainable Based on Available AEP Information[2]
Butte Basin (5)	0.500	0.280
Grimes (10)	0.040	0.533
South Sutter (11/34)	0.500	0.255
K. Landing (13/14)	0.040	0.070
Yolo (15)	0.500	0.074
Woodland (16)	0.040	0.090
Davis (17)	0.040	0.040
Linda (27)	0.010	0.008
Rio Oso (30)	0.200	0.086
North Sutter (32)	0.040	0.050
Elkhorn (35)	0.040	0.500
Natomas (36)	0.010	0.007
Arden/Rio Linda (37)	0.010	0.010
West Sac (38)	0.040	0.009
Southport (39)	0.040	0.011
Sacramento (40)	0.040	0.008
Clarksburg (42)	0.020	0.131
Merritt Island (46)	0.040	0.156
Sutter Island (49)	0.500	0.103
Grand Island (50)	0.040	0.108
Tyler Island (53)	0.200	0.805
Brannan Andrus (54)	0.040	0.552
Ryer Island (55)	0.100	0.124
Hastings Tract (61)	0.500	0.329

[1]AEP information associated with Condition A from URS Report
[2]AEP information taken from the Comprehensive Study, or when available, from a more current District study

10.9 Economic Impact Area Groupings for Net Benefit and Benefit-to-Cost Analyses

For purposes of this report, the net benefit and benefit-to-cost analyses were performed by individual impact area/basin and by groups of impact areas based on the consequences of flooding within a particular impact area. The consequences of flooding criteria used to group the impact areas include the type and amount of damages and the population at risk. Table 15 lists the consequences of flooding, in terms of agricultural and urban damages and population at risk, from a 1% exceedance probability event. It should be noted that Table 15 shows the damage values from a 1% exceedance probability event and is computed with engineering uncertainty as well as using a geotechnical levee fragility curves while the tables contained in Enclosure 6 show ACE damages, which are computed without engineering uncertainty and without using a geotechnical levee fragility curve.

Table 15: Consequences of Flooding from a 1% Exceedance Probability Flood Event (October 2012 Price Level, in $1,000s)

	CONSEQUENCES		
Economic Impact Area	**Agricultural Damages (in $1,000s)**	**Urban Damages (in $1,000s)**	**Population at Risk (Number of People)**
Butte Basin (5)	135,443	0	380
Grimes (10)	43,675	3	142
South Sutter (11/34)	62,759	3,105	49
K. Landing (13/14)	5,851	30,537	786
Yolo (15)	4,300	0	3
Woodland (16)	1,881	0	--
Davis (17)	29	3,263	255
Linda (27)	2,286	4,559	4,100
Rio Oso (30)	633	7,298	186
North Sutter (32)	47,686	3,894	380
Elkhorn (35)	39,674	0	--
Natomas (36)	0	0	100,000
Arden/Rio Linda (37)	0	0	44,216
West Sac (38)	58	1,613,730	50,515
Southport (39)	244	1,262,875	
Sacramento (40)	54	3,946,021	371,244
Clarksburg (42)	5,686	0	331
Merritt Island (46)	5,556	8,908	421
Sutter Island (49)	11,578	777	15
Grand Island (50)	28,471	0	--
Tyler Island (53)	7,246	0	6
Brannan Andrus (54)	15	0	9
Ryer Island (55)	11,100	88	9
Hastings Tract (61)	1,939	0	--
TOTAL	**416,163**	**6,885,058**	**573,047**

The first group of impact areas includes those impact areas that contain predominantly agricultural land uses; the second group includes those impact areas that contain predominantly urban land uses; the third group includes those impact areas that cannot be characterized as predominantly agricultural or urban and could be considered "mixed" use; the fourth group is comprised of all impact areas. Table 16 below lists the groups of impact areas by predominant land use.

Table 16: Groups of Impact Areas by Predominant Land Use

Predominant Land Use	Economic Impact Area/Sub-Basin
Predominantly Agricultural	Butte Basin (5); South Sutter (11/34); Yolo (15); Rio Oso (30); North Sutter (32); Elkhorn (35); Merritt Island (46); Sutter Island (49); Grand Island (50); Tyler Island (53); Brannan Andrus Island (54); Ryer Island (55); Hastings Tract (61)
Predominantly Urban	Knights Landing (13/14); Woodland (16); Davis (17); Linda (27); Natomas (36); Arden (37); West Sacramento (38); Southport (39); Sacramento (40)
Mixed Use	Grimes (10); Clarksburg (42)

11. RESULTS: NET BENEFIT AND BENEFIT-TO-COST ANALYSES

The following sub-sections describe the results of the net benefit and benefit-to-cost analyses. The first section presents the results from a Sacramento Basin and land-use perspective by combining sub-basins within the Sacramento Basin by major land use. The second section presents the results from a sub-basin perspective, presenting net benefits and benefit-to-cost ratios by individual impact area.

11.1 Net Benefit and Benefit-to-Cost Analyses by Analysis Group and Sacramento Valley System

Table 17 below displays the without-project expected annual damages (EAD) for each analysis group.

Table 17: Without-Project Expected Annual Damages (EAD) by Analysis Group (October 2012 Price Level, in $1,000s)

Analysis Group	Damage Consequences							Total
	AUTO	COM	IND	RES	PUB	FARM	CROPS	
Agricultural	240	143	184	962	261	0	43,224	**45,014**
Urban	16,477	56,474	52,092	223,537	29,330	117	444	**378,473**
Mixed	1	2	1	9	3	0	1,983	**1,999**
Total	**16,718**	**56,619**	**52,277**	**224,508**	**29,594**	**117**	**45,651**	**425,486**

Table 18 below displays the without-project EAD, with-project residual EAD, and average annual benefits for each group evaluated.

Table 18: Without-Project EAD, With-Project Residual EAD, & Average Annual Benefits by Analysis Group (October 2012 Price Level, 50-Year Period of Analysis, in $1,000s)

Analysis Group	Without-Project EAD	With-Project Residual EAD	Expected Average Annual Benefits
Agricultural	45,014	37,232	**7,782**
Urban	378,473	206,781	**171,692**
Mixed	1,999	1,999	**0**
Total	**425,486**	**246,441**	**179,474**

Table 19 shows the distribution of benefits – the chance benefits exceed an indicated value – for each analysis group. The range of benefits, to an extent, can indicate the amount of uncertainty associated with the benefit values. The range in benefits for the urban analysis group is large, which may indicate a high uncertainty with the average annual benefit value for this group. In light of this, the benefit values (for all groups) having a 75% chance of being exceeded were used in the benefit-to-cost ratio calculations (Table 21 below).

Table 19: Probability Benefits Exceed Indicated Value by Analysis Group (October 2012 Price Level, in $1,000s)

Analysis Group	Without-Project EAD	With-Project Residual EAD	Expected Average Annual Benefits	Probability Benefits Exceeds Indicated Value		
				.75	**.50**	**.25**
Agricultural	45,014	37,232	7,782	7,434	7,729	8,167
Urban	378,473	206,781	171,692	63,607	134,187	270,566
Mixed	1,999	1,999	0	0	0	0
Total	425,486	246,012	179,474	71,041	141,916	278,733

For reference purposes, Table 12 is presented again as Table 20 below, which shows the average annual costs by analysis group used in the net benefit and benefit-to-cost analyses.

Table 20: Total Project Costs, IDC, Total Investment Costs, & Average Annual Costs (October 2012 Price Level, 3.75% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Analysis Group Based on Predominant Land Use	Total Project Costs	Interest During Construction (IDC)	Total Investment Costs	Average Annual Costs
Agricultural	297,256	9,117	306,373	13,657
Urban	40,231	843	41,074	1,833
Mixed[1]	23,143	398	23,541	1,049
Total	**360,630**	**10,358**	**370,988**	**16,539**

[1]Mixed refers to those areas that cannot be characterized as either predominantly urban or agricultural.

Table 21 below displays the average annual benefits (from Table 18 above) by analysis group, average annual costs by analysis group (from Table 20 above), net benefits (average annual benefits minus average annual costs), and benefit-to-cost ratios (average annual benefits divided by average annual costs) for each analysis group.

Table 21: Annual Benefits, Average Annual Costs, Net Benefits, & Benefit-to-Cost Ratios by Analysis Group (October 2012 Price Level, 3.75% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Analysis Group	Annual Benefits (75% Confidence Level)	Average Annual Costs	Net Benefits	Benefit-to-Cost Ratio (BCR)
Agricultural	7,434	13,657	(6,223)	0.5
Urban	63,607	1,833	61,774	35.0
Mixed	0	1,049	(1,049)	0.0
Total	**71,041**	**16,539**	**54,502**	**4.0**

Note: Annual benefits (column 2) used in this table were taken from Table 18 and represent the benefit values having a 75% chance of being exceeded; these lower values were used in the benefit-to-cost ratio calculations in recognition of the uncertainty in both the data inputs and process used to estimate benefits.

11.2 Net Benefit and Benefit-to-Cost Analyses by Sub-Basin (Impact Area)

While analyzing the Sacramento Basin as a whole produces positive net benefits and a benefit-to-cost ratio above unity, the results are different when an incremental analysis is performed by individual impact area/sub-basin. Table 22 displays the expected benefits by impact area; Table 23 displays a range of benefits by impact area/basin. A summary of the net benefits and benefit-to-cost ratios for these impact areas is provided in Table 24 below.

Table 22: Without-Project EAD, With-Project Residual EAD, & Expected Benefits by Impact Area/Sub-Basin

Impact Area/Sub-Basin	Without-Project Damages	With-Project Residual Damages	Expected Annual Benefits
Butte Basin (5)	28,516	24,086	4,430
Grimes (10)	1,859	1,859	0
South Sutter (11/34)	6,661	4,977	1,684
K. Landing (13/14)	1,077	1,077	0
Yolo (15)	845	274	571
Woodland (16)	74	74	0
Davis (17)	197	197	0
Linda (27)	277	234	43
Rio Oso (30)	1,163	749	414
North Sutter (32)	618	618	0
Elkhorn (35)	1,379	1,379	0
Natomas (36)	72,190	51,823	20,367
Arden/Rio Linda (37)	37,698	37,698	0
West Sac (38)	77,034	31,849	45,185
Southport (39)	66,991	19,051	47,940
Sacramento (40)	123,367	65,203	58,164
Clarksburg (42)	141	141	0
Merritt Island (46)	310	310	0
Sutter Island (49)	1,579	912	667
Grand Island (50)	1,014	1,014	0
Tyler Island (53)	1,310	1,310	0
Brannan Andrus (54)	580	580	0
Ryer Island (55)	707	707	0
Hastings Tract (61)	331	316	15
TOTAL	**425,486**	**246,012**	**179,474**

Table 23: Probability Benefits Exceed Indicated Value by Impact Area/Sub-Basin (October 2012 Price Level, 50-Year Period of Analysis, in $1,000s)

Impact Area/Sub-Basin	Without-Project EAD	With-Project Residual EAD	Expected Average Annual Benefits	Probability Benefits Exceeds Indicated Value		
				.75	.50	.25
Butte Basin (5)	28,516	24,086	4,430	4,331	4,466	4,521
Grimes (10)	1,859	1,859	0	0	0	0
South Sutter (11/34)	6,661	4,977	1,684	1,562	1,576	1,851
K. Landing (13/14)	1,077	1,077	0	0	0	0
Yolo (15)	845	274	571	535	576	611
Woodland (16)	74	74	0	0	0	0
Davis (17)	197	197	0	0	0	0
Linda (27)	277	234	43	9	64	66
Rio Oso (30)	1,163	749	414	362	413	465
North Sutter (32)	618	618	0	0	0	0
Elkhorn (35)	1,379	1,379	0	0	0	0
Natomas (36)	72,190	51,823	20,367	17,282	20,685	23,515
Arden/Rio Linda (37)	37,698	37,698	0	0	0	0
West Sac (38)	77,034	31,849	45,185	13,809	44,814	78,042
Southport (39)	66,991	19,051	47,940	13,161	28,167	70,289
Sacramento (40)	123,367	65,203	58,164	18,321	37,685	93,020
Clarksburg (42)	141	141	0	0	0	0
Merritt Island (46)	310	310	0	0	0	0
Sutter Island (49)	1,579	912	667	630	683	703
Grand Island (50)	1,014	1,014	0	0	0	0
Tyler Island (53)	1,310	1,310	0	0	0	0
Brannan Andrus (54)	580	580	0	0	0	0
Ryer Island (55)	707	707	0	0	0	0
Hastings Tract (61)	331	316	15	14	15	16

Table 24: Annual Benefits, Average Annual Costs, Net Benefits, & Benefit-to-Cost Ratios by Impact Area/Sub-Basin (October 2012 Price Level, 3.75% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Impact Area/Sub-Basin	Annual Benefits (75% Confidence Level)	Average Annual Costs	Net Benefits	Benefit-to-Cost Ratio (BCR)
Butte Basin (5)	4,331	441	3,890	10
Grimes (10)	0	586	0	N/A
South Sutter (11/34)	1,562	2,818	(1,256)	0.60
K. Landing (13/14)	0	473	0	N/A
Yolo (15)	535	103	432	5.2
Woodland (16)	0	229	0	N/A
Davis (17)	0	23	0	N/A
Linda (27)	9	137	(128)	0.10
Rio Oso (30)	362	314	48	1.2
North Sutter (32)	0	649	0	N/A
Elkhorn (35)	0	349	0	N/A
Natomas (36)	17,282	120	17,162	144
Arden/Rio Linda (37)	0	N/A	0	N/A
West Sac (38)	13,809	73	13,736	189
Southport (39)	13,161	443	12,718	30
Sacramento (40)	18,321	335	17,986	55
Clarksburg (42)	0	463	0	N/A
Merritt Island (46)	0	380	0	N/A
Sutter Island (49)	630	613	17	1.0
Grand Island (50)	0	548	0	N/A
Tyler Island (53)	0	5,963	0	N/A
Brannan Andrus (54)	0	967	0	N/A
Ryer Island (55)	0	349	0	N/A
Hastings Tract (61)	14	163	(149)	0.10

12. ENGINEERING PERFORMANCE STATISTICS FOR ECONOMICALLY JUSTIFIED BASINS

The engineering performance statistics for those areas that are economically justified are presented in Table 25 below. It must be emphasized that the “without-project” AEP values were attained using available data and through non-standard techniques using the HEC-FDA software; Section 10.8 explains how these “without-project” target AEP values were achieved. This non-standard approach was used in the absence of more standard engineering data (e.g., without-project levee fragility curves) and was believed to be viable approach to measure economic outputs associated with erosion repairs (and only erosion repairs) to the levees within each sub-basin. In addition to the AEP values, Table 25 also displays the long-term risk and assurance results for those sub-basins that have a positive BCR. Long-term risk describes the chance of flooding over a specific time period, for example 30 years; assurance describes the chance of passing a specific exceedance probability event, for example the 1% exceedance probability event, without sustaining significant flooding.

It must be reiterated that the analysis for this PACR brings forward the analysis performed for a previous economic analysis. In doing so, the analysis focused mainly on benefit estimation using available data as well as non-standard techniques in HEC-FDA. In light of this, the engineering performance statistics may not be completely representative of a particular sub-basin/erosion site, especially in cases where the “without-project” AEP is actually greater than the “with-project” AEP. The AEP values used in the analysis are a compilation of existing data, taken from multiple sources, developed using different methods, and used primarily to measure the difference between a “without-project” condition and a “with-project” condition in order to estimate the benefits of a sub-basin.

In order to resolve those cases where the “with-project” AEP is greater than the “without-project” AEP, more current data/information needs to be provided and a more standard economic risk analysis would have to be performed.

Table 25: Engineering Performance Statistics for Sub-Basins with a Positive BCR

Without-Project Condition Performance Statistics										
		Long-Term Risk			Assurance					
EIA	AEP	10	30	50	10%	4%	2%	1%	.4%	.2%
Butte Basin	0.500	99%	99%	99%	0%	0%	0%	0%	0%	0%
Yolo	0.500	99%	99%	99%	4%	2%	2%	1%	0%	0%
Rio Oso	0.200	90%	99%	99%	25%	16%	10%	8%	0%	0%
Natomas	0.010	10%	23%	40%	97%	95%	94%	90%	69%	54%
West Sac	0.040	34%	64%	88%	91%	60%	53%	33%	13%	10%
Southport	0.040	34%	65%	87%	87%	74%	72%	68%	65%	65%
Sacramento	0.040	34%	71%	87%	98%	51%	37%	26%	18%	10%
Sutter Is.	0.500	99%	99%	99%	13%	1%	0%	0%	0%	0%
With-Project Condition Performance Statistics										
		Long-Term Risk			Assurance					
EIA	AEP	10	30	50	10%	4%	2%	1%	.4%	.2%
Butte Basin	0.280	96%	99%	99%	0%	0%	0%	0%	0%	0%
Yolo	0.074	54%	85%	98%	67%	36%	28%	14%	0%	0%
Rio Oso	0.086	59%	93%	99%	67%	48%	37%	33%	0%	0%
Natomas	0.007	7%	17%	31%	99%	95%	94%	90%	69%	53%
West Sac	0.009	9%	21%	37%	99%	93%	91%	80%	52%	45%
Southport	0.011	11%	25%	44%	96%	92%	92%	90%	89%	89%
Sacramento	0.008	8%	21%	33%	99%	95%	88%	78%	66%	50%
Sutter Is.	0.103	66%	96%	99%	55%	3%	1%	0%	0%	0%

13. Average Annual Damages, Benefits, Costs, Net Benefits, and BCRs for Eight Sub-Basins

The current update focuses on the eight sub-basins that were determined to be economically feasible; the assumptions, data, and methodologies used to make this determination were explained in the sections above. For the eight economically feasible sub-basins, the information presented in the previous sections was used to update the benefits for price level (October 2012 to October 2013). In addition, the District's Cost Engineering Section performed a complete revision of the costs associated with fixing the erosion sites.

Agricultural damages and benefits for four of the eight impact areas/sub-basins that are comprised predominantly of farmland were also reevaluated using the most current version of the agricultural model (SCARCE). SCARCE has recently gone through model review via the Planning Center of Expertise (PCX) in San Francisco and is awaiting official approval for use from Headquarters. The four impact areas that were reevaluated include Butte Basin, Yolo, Rio Oso, and Sutter Island.

Table 27 below summarizes the updated damages benefits; Tables 28 and 29 summarize the revised costs at 3.50% and 7.00% discount rates, respectively; and Tables 30 and 31 show the net benefit and benefit-to-cost ratio analyses at 3.50% and 7.00% discount rates, respectively .

Table 26: Updated Damages and Benefits for Eight Sub-Basins – Agricultural and Urban (October 2013 Price Level, 3.50% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Impact Area/Sub-Basin	WO EAD - Urban	WO EAD - Urban Residual	Expected Benefits - Urban	Annual Benefits (75% Confidence Level)	WO EAD – Agricult.	WO EAD – Agricult. Residual	Expected Benefits – Agricult.	Annual Benefits – Agricult. (75% Confidence Level)	Total Avg. Ann. Benefits
Butte Basin (5)	--	--	--	--	6,595	5,550	1,045	1,028	1,028
Yolo (15)	--	--	--	--	940	139	801	770	770
Rio Oso (30)	857	452	405	353	968	470	498	443	796
Natomas (36)	73,201	52,549	20,652	17,524	--	--	--	--	17,524
West Sac (38)	78,112	32,295	45,817	13,995	--	--	--	--	13,995
Southport (39)	67,929	19,318	48,611	13,345	--	--	--	--	13,345
Sacramento (40)	125,094	66,116	58,978	18,577	--	--	--	--	18,577
Sutter Island (49)	53	50	3	2	441	89	351	347	349
Total	**345,246**	**170,780**	**174,466**	**63,796**	**8,944**	**6,248**	**2,695**	**3,553**	**66,384**

Table 27: Costs of Fixing Erosions Sites in Eight Sub-Basins (October 2013 Price Level, 3.50% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Impact Area (Basin)	Total Project Costs	Interest During Construction (IDC)	Total Investment Costs	Average Annual Costs
Butte Basin (5)	12,658	202	12,860	548
Yolo (15)	5,637	90	5,727	244
Rio Oso (30)	7,713	123	7,836	334
Natomas (36)	2,788	44	2,832	121
West Sacramento (38)	2,186	35	2,221	95
Southport (39)	10,345	165	10,510	448
Sacramento (40)	1,299	21	1,320	56
Sutter Island (49)	11,353	181	11,534	492
TOTAL	**53,979**	**861**	**54,840**	**2,338**

Table 28: Costs of Fixing Erosions Sites in Eight Sub-Basins (October 2013 Price Level, 7.00% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Impact Area (Basin)	Total Project Costs	Interest During Construction (IDC)	Total Investment Costs	Average Annual Costs
Butte Basin (5)	12,658	401	13,059	946
Yolo (15)	5,637	179	5,816	421
Rio Oso (30)	7,713	244	7,957	577
Natomas (36)	2,788	88	2,876	208
West Sacramento (38)	2,186	69	2,255	163
Southport (39)	10,345	328	10,673	773
Sacramento (40)	1,299	41	1,340	97
Sutter Island (49)	11,353	360	11,713	849
TOTAL	**53,979**	**1,710**	**55,689**	**4,035**

Table 29: Annual Benefits, Average Annual Costs, Net Benefits, & Benefit-to-Cost Ratios for Economically Feasible Impact Areas/Sub-Basins (October 2013 Price Level, 3.50% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Impact Area/Sub-Basin	Annual Benefits (75% Confidence Level)	Average Annual Costs	Net Benefits	Benefit-to-Cost Ratio (BCR)
Butte Basin (5)	1,028	548	480	1.9 to 1
Yolo (15)	770	244	526	3.2 to 1
Rio Oso (30)	796	334	462	2.4 to 1
Natomas (36)	17,524	121	17,403	145 to 1
West Sac (38)	13,995	95	13,900	147 to 1
Southport (39)	13,345	448	12,897	30 to 1
Sacramento (40)	18,577	56	18,521	332 to 1
Sutter Island (49)	349	492	(143)	0.7 to 1
TOTAL	**66,384**	**2,338**	**64,046**	**28 to 1**

Table 30: Annual Benefits, Average Annual Costs, Net Benefits, & Benefit-to-Cost Ratios for Economically Feasible Impact Areas/Sub-Basins (October 2013 Price Level, 7.00% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Impact Area/Sub-Basin	Annual Benefits (75% Confidence Level)	Average Annual Costs	Net Benefits	Benefit-to-Cost Ratio (BCR)
Butte Basin (5)	1,028	946	82	1.1 to 1
Yolo (15)	770	421	349	1.8 to 1
Rio Oso (30)	796	577	219	1.4 to 1
Natomas (36)	17,524	208	17,316	84 to 1
West Sac (38)	13,995	163	13,832	86 to 1
Southport (39)	13,345	773	12,572	17 to 1
Sacramento (40)	18,577	97	18,480	191 to 1
Sutter Island (49)	349	849	(500)	0.4 to 1
TOTAL	**66,384**	**4,035**	**62,349**	**16 to 1**

14. CONCLUSIONS

Without-project damages are based on the contractor-developed AEP information for Condition A (without-project target AEPs). As was mentioned previously, this information is not based on a traditional geotechnical engineering analysis for purposes of characterizing, in detail, the conditions of the levees at the erosion sites, but instead was developed specifically for purposes of providing information for input into this economic analysis. In light of this, it is recognized that there is uncertainty regarding the AEP information used in this analysis, which in turn introduces uncertainty in the project benefits reported here.

It is also recognized that the process to achieve the contractor-developed without-project AEP values entails adjusting the probabilities of failure on the geotechnical fragility curves by trial and error in order to produce the target AEP results. As a result of this trial and error process, there is the possibility that there is more than one way (i.e., different ways to adjust the fragility curves) to get to the target AEPs. This introduces additional uncertainty associated with the project benefits.

In recognition of both the uncertainty in the contractor-developed target AEP values and the uncertainty in the process of achieving these values in HEC-FDA using adjusted fragility curves, a distribution (or range) of benefits was reported. It is important to note that for this report, the benefit values having a 75% chance of being exceeded were used in the net benefit and benefit-to-cost calculations for each evaluation group and for each impact area/sub-basin.

Residual risk in terms of damage consequences and population at risk remains high even after the erosion stabilization work. For this analysis, only failure due to erosion was considered; other mechanisms of levee failure, such as under seepage, through seepage, and stability issues, were not considered. This constraint is directly reflected in the amount of benefits being realized for those sub-basins where improvements to specific erosion sites do not necessarily result in a reduction in residual risk.

In certain impact areas, without-project target AEP values are lower than or equal to the “with-project” AEP values pulled from either the Comprehensive Study analysis or another District Study. For these areas, based solely on the “pre-project” and “post-project” AEP values assumed for this analysis, benefits were not claimed, which is reflected in the benefit-to-cost ratios by evaluation group and by impact area/sub-basin. As was mentioned previously, many of the AEP values assumed for this analysis were those currently available from the 2002 Comprehensive Study, which may in itself have a certain amount of uncertainty attached to it due to its lack of currency. From this perspective, then, benefits may well be higher than which are reported here and which were used to calculate net benefits and benefit-to-cost ratios.

In factoring in all of the uncertainty with the data used in the analysis and the uncertainty inherent to the analytical approach used to estimate benefits, the analysis indicates that there are seven sub-basins with positive net benefits and benefit-to-cost ratios above unity. These are listed in Table 31 below and include the Butte Basin, Yolo, Rio Oso, Natomas, West Sacramento, Southport, and Sacramento sub-basins/impact areas. It should be noted that Sutter Island, which was determined to be economically feasible during the last update, is now determined to be economically infeasible. Table 31 displays the net benefit and BCR analyses for the economically feasible sub-basins/impact areas.

Table 31: Annual Benefits, Average Annual Costs, Net Benefits, & Benefit-to-Cost Ratios for Economically Feasible Impact Areas/Sub-Basins (October 2013 Price Level, 3.50% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Impact Area/Sub-Basin	Annual Benefits (75% Confidence Level)	Average Annual Costs	Net Benefits	Benefit-to-Cost Ratio (BCR)
Butte Basin (5)	1,028	548	480	1.9 to 1
Yolo (15)	770	244	526	3.2 to 1
Rio Oso (30)	796	334	462	2.4 to 1
Natomas (36)	17,524	121	17,403	145 to 1
West Sac (38)	13,995	95	13,900	147 to 1
Southport (39)	13,345	448	12,897	30 to 1
Sacramento (40)	18,577	56	18,521	332 to 1
TOTAL	**66,035**	**1,846**	**64,189**	**36 to 1**

Table 32: Annual Benefits, Average Annual Costs, Net Benefits, & Benefit-to-Cost Ratios for Economically Feasible Impact Areas/Sub-Basins (October 2013 Price Level, 7.00% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Impact Area/Sub-Basin	Annual Benefits (75% Confidence Level)	Average Annual Costs	Net Benefits	Benefit-to-Cost Ratio (BCR)
Butte Basin (5)	1,028	946	82	1.1 to 1
Yolo (15)	770	421	349	1.8 to 1
Rio Oso (30)	796	577	219	1.4 to 1
Natomas (36)	17,524	208	17,316	84 to 1
West Sac (38)	13,995	163	13,832	86 to 1
Southport (39)	13,345	773	12,572	17 to 1
Sacramento (40)	18,577	97	18,480	191 to 1
TOTAL	**66,035**	**3,185**	**62,850**	**21 to 1**

ENCLOSURE 1

Annual Probability of Failure and Sensitivity Analysis Due to Bank Erosion

URS Corporation (Feb 2011)

DRAFT

Annual Probability of Failure and Sensitivity Analysis Due to Bank Erosion

Sacramento River Bank Protection Project, Phase II Evaluation Report, Sacramento, CA: Economic Studies

Prepared by

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2870 Gateway Oaks Drive, Suite 150
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Contract W91238-09-D-0029
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Prepared for

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Sacramento, CA 95814-2922

February 2011

STATEMENT OF COMPLETION OF INDEPENDENT TECHNICAL REVIEW

The A-E Contractor, Brown and Caldwell- URS Corporation (URS) Joint Venture, has estimated Annual Exceedance Probability (AEP) and performed Sensitivity Analysis for 107 erosion sites identified by the USACE annual field reconnaissance review within 40 economic impact areas.

Notice is hereby given that an independent technical review (ITR) appropriate to the standard of care was conducted as defined in the Project Plan. The ITR also complied with established URS policy, principles and procedures as required for review of a project of this nature.

The ITR included reviewing data review methods, field inspection methods, field data collection methods, AEP estimating methods, and the sensitivity analysis methodology and results as per USACE requirements.

ITR comments were reviewed, discussed and finalized before they were incorporated into this report.

Loren A. Murray — 2/7/2011

Independent Technical Reviewer — Date

Jeff I. — 2/7/2011

Project Manager, A-E Contractor — Date

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Appendix C:	Sensitivity Analysis Calculations

Acronyms and Abbreviations

AEP	annual exceedance probability
DWR	California Department of Water Resources
EIS/EIR	Environmental Impact Statement/Environmental Impact Report
JV	Brown and Caldwell-URS Joint Venture
ID	Identification
LiDAR	Light Detection and Ranging
PAC	Post Authorization Change
SRBPP	Sacramento River Bank Protection Project
ULE	Urban Levee Geotechnical Evaluations Program
USACE	U.S. Army Corps of Engineers
$P_{(fE)}$	Formula Symbol for Annual Exceedance Probability for Levee Failure due to Erosion
V_h	Formula Symbol for River Velocity
V_{EFS}	Formula Symbol for Velocity In Erosion Function Apparatus Test
R_E	Erosion Rate
S	Formula Symbol for Site Factor
W_R	Formula Symbol for Erosion Width
W_E	Formula Symbol for Effective Levee Width

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1.0 INTRODUCTION

1.1 Purpose

This paper provides estimates of annual exceedance probability (AEP) for levee failure due to erosion. Erosion may lead to structural degradation of the levee, increasing the risk failure, flood inundation and damages interior of a levee. The U.S. Army Corps of Engineers' (USACE's) Sacramento District requested AEP estimates for four specified conditions:

- Condition A: Without project existing condition without flood in 2010
- Condition B: Without project existing condition with flood in 2010
- Condition C: Without project future condition with flood in 2025
- Condition D: With project condition

USACE is developing a Phase II Post Authorization Change (PAC) Environmental Impact Statement/Environmental Impact Report (EIS/EIR) and supporting documents for levee repairs to be performed under the Sacramento River Bank Protection Program (SRBPP). SRBPP will address changes to land use, economic conditions, environmental conditions, and updated information about levee failure mechanisms associated with remedial treatment of project levees.

This paper provides a quantitative AEP associated with levee failures caused by bank erosion in 40 economic impact areas (at 107 selected erosion sites) under consideration for repair.

These AEPs were prepared under the assumption that they will be used for prioritizing, screening, and developing net benefits for selecting project sites for the SRBPP *Phase II Evaluation Report*, Sacramento, California: Economic Studies.

1.2 Authorization

This evaluation project is conducted by the Brown and Caldwell-URS Joint Venture (JV) for USACE's Sacramento District under contract W91238-09-D-0029's Delivery Order No. 0003.

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2.0 BACKGROUND

The Sacramento River Flood Control Project is a system of levees, weirs, pumping plants, and bypasses designed to safely convey Sacramento River and tributary flood flows. The project provides protection to about 2.1 million acres of highly productive agricultural land, as well as protection to the cities of Sacramento, West Sacramento, Yuba City, Marysville, Colusa, Gridley, and other communities. There are approximately 1,300 miles of project levees in this system.

The SRBPP is a federal program that inspects the Sacramento River Flood Control Project levees and associated natural banks and berms, identifying and ranking erosion problems, and providing remedial repairs. The SRBPP is a continuing construction project authorized by Section 203 of the Flood Control Act of 1960. The California Department of Water Resources' (DWR's) Central Valley Flood Protection Board is the SRBPP's non-federal sponsor.

To date, SRBPP work has occurred in two phases, during which a total of about 840,000 feet of river levee have been stabilized. SRBPP's Phase I consisted of inspection and repairs to 430,000 feet of levee; Phase II's original authorization included inspecting and repairing 390,000 feet of levee.

Current SRBPP inspection and repair work is being conducted under Phase II of its existing federal authorization, with approximately 15,646 feet remaining. An additional 80,000 feet of bank protection was authorized by the Water Resources Development Act of 2007. These additional feet were added to the SRBPP's Phase II work, increasing Phase II's authorization to 485,000 feet of levee. The USACE and the Central Valley Flood Protection Board are in the process of preparing an EIS/EIR for this supplemental authorization.

The SRBPP recently began planning and developing Phase III; Phase III will ensure that any project levees seriously threatened by erosion will continue to receive corrective measures to prevent levee failure, catastrophic damage or possible loss of life.

As part of the SRBPP, USACE's Sacramento District and DWR conduct an annual field reconnaissance review and maintain an inventory of erosion sites in the Sacramento River basin and northern Delta. The USACE has currently identified 107 erosion sites for evaluation of their probability of failure due to erosion or other failure mechanisms. This evaluation is being carried out under the SRBPP's Phase II. Evaluation results will be used to prioritize, screen, and develop net benefits for selected projects.

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3.0 TECHNICAL APPROACH

This evaluation study entailed three major efforts:

- Field observations and evaluations at each of the 107 erosion sites.

  Each of the 107 sites was visited in the field. Field observations documented 13 characteristics (bank and levee slope, soil type in bank and within the waterside slope, waterside berm width, water velocity, animal activity, and vegetation cover, etc.). Based on these observations, a weighted site characterization score for each site was calculated.
- Estimating the probability of failure due to bank erosion and a sensitivity analysis of key elements that promote erosion process.

  The AEPs of each site were estimated based on the nine-step process described in Appendix A. A sensitivity analysis for 10 of the 107 sites was completed. This paper summarizes these activities and gives the results of the field observation and erosion AEP estimation efforts.
- Estimating the probability of failure due to other failure modes.

  Following this paper, an *Evaluation of Other Probability Failure Scenarios and Economic Impact Area Report* will evaluate the probability of failure associated with other failure mechanisms (stability issues, through seepage, and underseepage). Erosion can contribute to some of the other failure mechanisms that will be evaluated. The *Evaluation of Other Probability Failure Scenarios and Economic Impact Area Report* will use the erosion effects estimated in this report to determine the contribution of erosion to a probability of failure through these other mechanisms.

3.1 Evaluating Procedure

This report focuses on estimating bank erosion and the AEP of levee failure due to bank erosion. The following approach was used to assess AEP for levee failure due to erosion:

1. Conduct a literature search using existing USACE and DWR data sources for information about the selected erosion sites.
2. Perform field observations and describe field conditions at the 107 erosion sites:
   - Describe the physical and geotechnical characteristics of the levee, levee foundation, and adjacent area
   - Numerically weigh and score erosion characteristics using 13 criteria on a field observation checklist (Appendix B contains field observation checklists)
   - Develop a judgment-based AEP for levee failure due to erosion observed in the field
3. Evaluate erosion severity (after field observations) using an nine-step method that considers the levee's geometry, the standard design levee prism, and the erosion rate of the levee's material. Erosion severity is expressed as a ratio of erosion width and effective levee width; it projects the AEP of levee failure due to erosion. This nine-step evaluation method is detailed in Appendix A.

4. Develop AEPs corresponding to the seven recurrence events pre-defined by USACE for the purposes of this project (i.e., annual event probabilities of 50%, 20%, 10%, 4%, 2%, 1% and 0.5%).
5. Estimate AEPs under the following four specified conditions:
   - Condition A: Without project existing conditions with no flood during 2010. This condition estimates AEP for levee failure based on current erosion severity against a standard levee design prism under a low flow condition.
   - Condition B: Without project existing conditions with a flood during 2010. This condition estimates the AEP for levee failure based on the conditions above, but adds projected erosion under an assumed flood condition during 2010.
   - Condition C: Without project future conditions with flood in 2025. This condition estimates AEP for levee failure based on a site's progressive erodibility from 2010 to 2025 based on initial field observations, and then adds projected erosion under an assumed design flood condition happening in 2025.
   - Condition D: With project conditions based on the probability of failure when a proposed erosion site is repaired to USACE standards.

3.2 Summary of USACE Identified Erosion Sites

The USACE annual field reconnaissance review has currently identified 107 erosion sites along the Sacramento River and tributaries. Table 1 provides detail information of number of sites located along Sacramento River and tributaries.

Table 1. Summary of Erosion Sites

Stream	No of Sites
Bear River	1
Cache Creek	1
Cache Slough	3
Cherokee Canal	2
Deep Water Ship Channel	2
Deer Creek	1
Elder Creek	3
Feather River	2
Georgiana Slough	17
Knight's Landing Ridge Cut	5
Lower American River	1
Natomas Cross Canal	1
Sacramento River	50
Steamboat Slough	7
Sutter Slough	2
Willow Slough	3
Yolo Bypass	5
Yuba River	1

3.3 Exceptions

Some exceptions to the evaluating procedure, discussed in section 3.1, were considered at the following sites due to their unique characteristics.

3.3.1 Erosion Sites DEC_2-4_L, ELC_1-4_L, ELC_3-0_R and ELC_4-1_L

For sites along Deer Creek and Elder Creek, levee crests were estimated to be 12 to 15 feet wide with a short freeboard. Erosion calculations were performed by placing the levee's prism at the crest of the levee using a standard levee width of 20 feet (see Appendix A for cross sections).

3.3.2 Erosion Sites Located Along Georgiana Slough

There are 17 erosion sites along the left bank of the Georgiana Slough. For most of these sites, the levee's bench is approximately 30 to 60% eroded. Trees along the edge of these benches have slumped to the base of the slope. Slumping and erosion have resulted in scalloped shorelines, with erosion scarps that are about 3 to 10 feet high. The potential for bank failure due to erosion and collapse of burrows extends to the toe of the waterside slope. At some locations, riprap is present locally along the river bank, as previous erosion repairs extend into the levee prism. Old brush boxes are present locally at eroded embankments. For erosion calculations, the most critical section of each site was considered.

During field observations, the water level was high and the levee waterside toe was not visible. Erosion below the water level was approximated for erosion calculations (see Appendix B for cross sections).

3.3.3 Erosion Sites SAC_163-0_L and SAC_168-3_L

Due to heavy vegetation on waterside berm, the waterside levee bank was not accessible at erosion sites on the right bank of the Sacramento River at SAC_163-0_L and SAC_168-3_L. Erosion estimates was calculated using USACE 2010 survey data (USACE, 2010).

3.4 AEP Considerations

Use of a consistent levee prism provides a uniform basis of comparison for all erosion sites; it establishes a minimum levee geometry requirement for evaluation of erosion impacts. The methodology used to estimate the AEP for levee failure due to erosion is described in Appendix A. In general, erosion sites with thick levees, wide berms and erosion-resistant soil material provide a higher factor of safety; they would be assigned low AEPs related to erosion. If erosion is observed well outside of the levee prism, then it is also assigned a low AEP. However, sites with deep erosion into the levee prism have a lower factor of safety and are therefore assigned high AEPs. Within the 107 erosion sites, many high and low AEP sites fall at both ends of erosion failure probability spectrum.

Erosion sites in the middle of the erosion failure probability spectrum rely more heavily on engineering judgment to establish an AEP. For example, a site with severe erosion near the water slope, but have extended bench on the waterside of the standard levee prism. Because of an extended bench and a higher factor of safety, a low AEP would be assigned. In this report, the distance of erosion from or into the levee prism is used to estimate the potential for levee failure. These distances are expressed as a ratio of "erosion width" (W_R) to "effective levee width" (W_E). Each erosion ratio was assigned an AEP value based on engineering judgment. For this evaluation, the breakdown of erosion ratios and assigned AEPs are shown in Table 2 and Table 3.

If erosion is completely outside the levee prism's waterside slope surface, use Table 2 is used to determine the AEP.

Table 2. Erosion Outside of Levee Prism and Annual Exceedance Probability.

Ratio of W_R/W_E	AEP
< 1%	0.5% (or 0.005)
1% to 5%	1% (or 0.01)
5% to 10%	2% (or 0.02)
> 10%	4% (or 0.04)

If erosion is partially or completely inside the levee prism's waterside slope surface, Table 3 is used to determine the AEP.

Table 3. Erosion Within Levee Prism and Annual Exceedance Probability.

Ratio of W_R/W_E	AEP
1% to 15%	4% (or 0.04)
15% to 20%	10% (or 0.1)
20% to 25%	20% (or 0.2)
> 25%	50% (or 0.5)

3.5 Reconciling Field Results with Calculations

When assigning a final AEP for levee failure due to erosion, an evaluation was performed to reconcile field observations and erosion severity calculations. Some AEPs made in the field observations were adjusted after erosion severity calculations were performed. For example, when a large portion of a levee bank was observed to be eroded, the field judgment-based AEP was assigned a high probability. After severity calculations were performed, it became apparent that some erosion sites were in wide levees. A portion of eroded bank in a wide levee has a lower probability of failure than a similar depth of erosion in a narrower levee. Accordingly, field judgment-based AEPs were adjusted to a lower probability, matching the severity calculation result.

Conversely, when the nine-step estimating method revealed erosion had cut into a large portion of a levee prism, some erosion sites with low-probability, judgment-based AEPs were adjusted to a higher probability.

Field observations indicated certain degrees of projected erosion based on the erosion characteristics of a site, such as flow velocity, levee soil material, vegetation density, geomorphology and other erosion-related aspects. This degree of projected erosion was reflected in the field-assigned AEP for Condition C. For Condition D, AEPs based on field observations were considered when estimating erosion potential in 2025.

Section 4.0 presents the AEP values from the reconciliation evaluation.

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4.0 RESULTS

Field observations were conducted between July 15 and August 13, 2010. The completed field observation checklists for all 107 sites are presented in Appendix B.

4.1 Conditions A, B and C

The AEP for specified Conditions A, B and C were assessed using the nine-step method described in Section 3.0 and detailed in Appendix A. Conditions A, B and C are defined in Step 5 of the technical approach detailed in Section 3.0. Derived estimates are presented below in Table 4. Cross section assessment and erosion severity calculations that were part of the nine-step method are included in Appendix B.

Table 4. Summary of AEPs Due to Erosion.

Reference No	Site ID	Erosion Site Location	AEP (Percent)		
			Condition A	Condition B	Condition C
1	BER_0-8_L	Bear River RM 0.8L	20	20	20
2	CHC_3-9_L	Cache Creek LM 3.9L	50	50	50
3	CHS_15-9_L	Cache Slough RM 15.9L	4	4	10
4	CHS_22-8_R	Cache Slough RM 22.8R	4	4	4
5	CHS_23-6_R	Cache Slough RM 23.6R	50	50	50
6	CKC_14_0_L	Cherokee Canal LM 14.0L	2	4	4
7	CKC_21-9_L	Cherokee Canal LM 21.9L	4	50	50
8	DWS_5-0_L	Deep Water Ship Channel LM 5.0L	0.5	0.5	0.5
9	DWS_5-01_L	Deep Water Ship Channel LM 5.01L	0.5	0.5	0.5
10	DEC_2-4_L	Deer Creek LM 2.4L	4	4	4
11	ELC_1-4_L	Elder Creek LM 1.4L	20	50	50
12	ELC_3-0_R	Elder Creek LM 3.0R	4	4	10
13	ELC_4-1_L	Elder Creek LM 4.1L	4	4	4
14	FHR_0-6_L	Feather River RM 0.6L	4	4	4
15	FHR_5-0_L	Feather River RM 5.0L	4	4	4
16	GEO_0-3_L	Georgiana Slough RM 0.3L	10	20	20
17	GEO_1-7_L	Georgiana Slough RM 1.7L	10	10	20
18	GEO_2-5_L	Georgiana Slough RM 2.5L	4	10	20
19	GEO_3-6_L	Georgiana Slough RM 3.6L	4	4	10
20	GEO_3-7_L	Georgiana Slough RM 3.7a/b	20	50	50
21	GEO_3-71_L	Georgiana Slough RM 3.7a/b	20	50	50

Table 4. Summary of AEPs Due to Erosion.

Reference No	Site ID	Erosion Site Location	AEP (Percent)		
			Condition A	Condition B	Condition C
22	GEO_4-0_L	Georgiana Slough RM 4.0L	4	4	10
23	GEO_4-3_L	Georgiana Slough RM 4.3L	4	4	4
24	GEO_4-5_L	Georgiana Slough RM 4.5L	4	4	4
25	GEO_4-6_L	Georgiana Slough RM 4.6L	4	4	10
26	GEO_5-3_L	Georgiana Slough RM 5.3L	20	50	50
27	GEO_6-1_L	Georgiana Slough RM 6.1L	4	4	10
28	GEO_6-4_L	Georgiana Slough RM 6.4L	4	4	10
29	GEO_6-6_L	Georgiana Slough RM 6.6L	4	4	10
30	GEO_6-8_L	Georgiana Slough RM 6.8L	4	4	10
31	GEO_8-3_L	Georgiana Slough RM 8.3L	4	4	10
32	GEO_9-3_L	Georgiana Slough RM 9.3L	10	10	20
33	KLR_0-2_R	Knights Landing Ridge Cut LM 0.2R	1	1	1
34	KLR_3-0_L	Knights Landing Ridge Cut LM 3.0L	4	4	4
35	KLR_3-1_L	Knights Landing Ridge Cut LM 3.1L	4	4	4
36	KLR_4-2_L	Knights Landing Ridge Cut LM 4.2L	4	10	10
37	KLR_5-3_L	Knights Landing Ridge Cut LM 5.3L	2	2	2
38	LAR_7-3_R	Lower American River, RM7.3R	1	4	4
39	NCC_3-0_R	Natomas Cross Canal LM 3.0R	4	4	4
40	SAC_21-5_L	Sacramento River RM 21.5L	4	4	4
41	SAC_22-5_L	Sacramento River RM 22.5L	4	4	4
42	SAC_22-7_L	Sacramento River RM 22.7L	4	4	10
43	SAC_23-2_L	Sacramento River RM 23.2L	4	4	10
44	SAC_23-3_L	Sacramento River RM 23.3L	4	4	4
45	SAC_24-8_L	Sacramento River RM 24.8L	4	10	20
46	SAC_25-2_L	Sacramento River RM 25.2L	4	4	10
47	SAC_31-6_R	Sacramento River RM 31.6R	4	4	10
48	SAC_35-3_R	Sacramento River RM 35.3R	0.5	0.5	0.5

Table 4. Summary of AEPs Due to Erosion.

Reference No	Site ID	Erosion Site Location	AEP (Percent)		
			Condition A	Condition B	Condition C
49	SAC_35-4_L	Sacramento River RM 35.4L	1	4	4
50	SAC_38-5_R	Sacramento River RM 38.5R	4	4	10
51	SAC_56-5_R	Sacramento River RM 56.5R	4	4	10
52	SAC_56-6_L	Sacramento River RM 56.6L	4	4	4
53	SAC_56-7_R	Sacramento River RM 56.7R	4	4	4
54	SAC_58-4_L	Sacramento River RM 58.4L	4	10	20
55	SAC_60-1_L	Sacramento River RM 60.1L	2	4	4
56	SAC_62-9_R	Sacramento River RM 62.9R	4	4	4
57	SAC_63-0_R	Sacramento River RM 63.0R	2	2	2
58	SAC_74-4_R	Sacramento River RM 74.4R	4	4	4
59	SAC_75-3_R	Sacramento River RM 75.3R	4	4	4
60	SAC_77-7_R	Sacramento River RM 77.7R	4	4	10
61	SAC_78-3_L	Sacramento River RM 78.3L	1	1	1
62	SAC_86-3_L	Sacramento River RM 86.3L	4	4	4
63	SAC_86-5_R	Sacramento River RM 86.5R	4	4	4
64	SAC_86-9_R	Sacramento River RM 86.9R	4	4	4
65	SAC_92-8_L	Sacramento River RM 92.8L	4	4	4
66	SAC_95-8_L	Sacramento River RM 95.8L	4	4	4
67	SAC_96-2_L	Sacramento River RM 96.2L	4	4	4
68	SAC_99-0_L	Sacramento River RM 99.0L	50	50	50
69	SAC_101-3_R	Sacramento River RM 101.3R	4	4	4
70	SAC_103-4_L	Sacramento River RM 103.4L	4	4	4
71	SAC_104-0_L	Sacramento River RM 104.0L	4	4	4
72	SAC_104-5_L	Sacramento River RM 104.5L	4	4	4
73	SAC_116-0_L	Sacramento River RM 116.0L	4	4	4
74	SAC_116-5_L	Sacramento River RM 116.5L	4	4	4
75	SAC_122-0_R	Sacramento River RM 122.0R	4	4	4

Table 4. Summary of AEPs Due to Erosion.

Reference No	Site ID	Erosion Site Location	AEP (Percent)		
			Condition A	Condition B	Condition C
76	SAC_122-3_R	Sacramento River RM 122.3R	4	4	4
77	SAC_123-3_L	Sacramento River RM 123.3L	4	4	4
78	SAC_123-7_R	Sacramento River RM 123.7R	4	4	4
79	SAC_127-9_R	Sacramento River RM 127.9R	4	4	4
80	SAC_131-8_L	Sacramento River RM 131.8L	4	4	4
81	SAC_132-9_R	Sacramento River RM 132.9R	4	4	4
82	SAC_133-0_L	Sacramento River RM 133.0L	4	4	4
83	SAC_133-8_L	Sacramento River RM 133.8L	4	4	4
84	SAC_136-6_L	Sacramento River RM 136.6L	4	20	20
85	SAC_138-1_L	Sacramento River RM 138.1L	4	4	4
86	SAC_152-8_L	Sacramento River RM 152.8L	50	50	50
87	SAC_163-0_L	Sacramento River RM 163.0L	4	4	4
88	SAC_168-3_L	Sacramento River RM 168.3L	4	50	50
89	SAC_172-0_L	Sacramento River RM 172.0	4	4	10
90	STM_18-8_R	Steamboat Slough RM 18.8R	10	20	20
91	STM_23-2_L	Steamboat Slough RM 23.2L	4	4	10
92	STM_23-9_R	Steamboat Slough RM 23.9R	4	4	10
93	STM_24-7_R	Steamboat Slough RM 24.7R	50	50	50
94	STM_25-0_L	Steamboat Slough RM 25.0L	4	4	10
95	STM_25-8_R	Steamboat Slough RM 25.8R	4	4	10
96	STM_26-0_L	Steamboat Slough RM 26.0L	4	4	10
97	STR_24-7_R	Sutter Slough RM 24.7R	2	4	4
98	STR_26-5_L	Sutter Slough RM 26.5L	4	4	10

Table 4. Summary of AEPs Due to Erosion.

Reference No	Site ID	Erosion Site Location	AEP (Percent)		
			Condition A	Condition B	Condition C
99	WSB_0-2_L	Willow Slough LM 2.2L (Location from GIS)	1	1	2
100	WSB_0-7_L	Willow Slough LM 0.6L (Location from GIS)	1	1	2
101	WSB_6-9_R	Willow Slough LM 6.9R	4	4	4
102	YOL_0-1_R	Yolo Bypass LM 0.1R	4	4	4
103	YOL_2-0_R	Yolo Bypass LM 2.0R	2	4	4
104	YOL_2-5_R	Yolo Bypass LM 2.5R	4	4	4
105	YOL_2-6_R	Yolo Bypass LM 2.6R	4	4	4
106	YOL_3-8_R	Yolo Bypass LM 3.8R	4	4	4
107	YUB_2-3_L	Yuba River LM 2.3L	1	1	1

4.2 Condition D

Condition D, as stated in Section 3.0, is "With project conditions based on the probability of failure when a proposed erosion site was repaired to USACE standards." A proposed erosion site is assumed to be repaired to USACE design and construction standards. It is also assumed that the risk of failure due to post-repair erosion will be minimized by the repair. For Condition D, the AEP is close to 0%. However, to remain consistent with the pre-selected probability values, the AEP for Condition D at any proposed site was assigned a value of 0.5%.

4.3 Uncertainty of Estimated AEP

As listed above, the estimated AEP for each condition is the mode, or the most likely occurrence, value. The maximum estimate of an AEP for levee failure due to erosion is approximated at 20% over the mode value. The minimum estimate of AEP due to erosion is 20% below the mode value. These uncertainty estimates were based on engineering judgment by assessing the erosion site data. For example: if the estimated AEP mode value is 50%, the maximum and minimum AEP estimates are 60% and 40%. Or, in another case, if the estimated AEP mode value is 2%, the maximum and minimum estimates are 2.4% and 1.6%.

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5.0 CONCLUSION

5.1 Condition A

Among the 107 selected erosion sites, 77 sites were estimated to have AEPs for levee failure at 4% under Condition A (i.e., "Without project existing conditions without flood during 2010."), there are five sites (Sites. CHC_3-9_L, CHS_23-6_R, SAC_99-0_L, SAC_152-8_L and STM_24-7_R) estimated to have AEPs for levee failure at 50%.

5.2 Condition B

For Condition B (i.e., "Without project existing conditions with flood during 2010."), the number of sites with an AEP for levee failure at 50 increases by six (Sites CKC_21-9_L, ELC_1-4_L, GEO_3-7_L, GEO_3-71_L, GEO_5-3_L and SAC_168-3_L), for a total of 11. There are six sites (Sites GEO_1-7_L, GEO_2-5_L, GEO_9-3_L, KLR_4-2_L, SAC_24-8_L and SAC_58-4_L) with an AEP of levee failure at 10%.

5.3 Condition C

For Condition C (i.e., "Without project future conditions with flood in 2025."), the number of sites with an AEP for levee failure at 50% remains unchanged. The number of sites with an AEP of levee failure at 10% increases by 19, up from six sites at Condition B, to a total of 25. The number of sites with an AEP of levee failure at 20% increase by five, up from four sites at Condition B, at a total of nine sites.

5.4 Condition D

The AEP estimate for "With Project Condition" is 0.5% for all 107 selected erosion sites. Table 5 summarizes the number of erosion sites with their AEPs at each of the three specified conditions.

Table 5. Numbers of Sites in Each AEP Choice Under Conditions A, B and C.

AEP (Percent)	Condition A	Condition B	Condition C
0.5	4	3	3
1	6	5	3
2	6	2	4
4	77	76	52
10	4	6	25
20	5	4	9
50	5	11	11

Figure 1 illustrates the number of erosion sites and their AEPs under each of the three specified conditions.

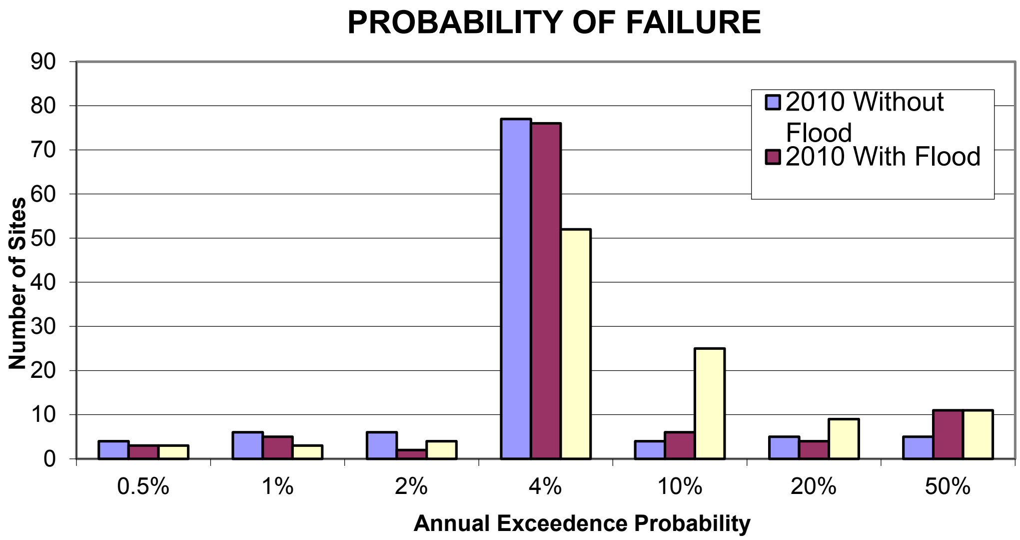

Figure 1. Number of Sites with AEPs Under Conditions A, B and C.

6.0 SENSITIVITY ANALYSIS

To perform a sensitivity analysis, 10 sites were selected to represent the general characteristics of the channel, such as tidal influence, bed material and channel geometry (slope, width, flow depth). Eight of the 10 sites were selected within the reach locations specified by USACE. Two sites (Sites GEO_9-3_L and BER_0.8_L) were selected to represent the Georgiana Slough and the Bear Creek. Table 6 lists the 10 selected sites.

Effects of particular input parameters on the AEP were identified through a sensitivity analysis. The following four input parameters were selected for sensitivity analysis:

- The hydrograph
- Placement of standard levee prism
- Erosion rate versus velocity
- Relationship between erosion width and probability of failure

For each selected representative site, the input parameter was increased and decreased by 25% and the AEPs for each site were calculated under each of the four conditions. These AEPs were compared to the originally-calculated AEPs. Appendix C contains the sensitivity analysis calculations.

Table 6. Sites selected for Sensitivity Analysis.

Reference No	Site ID	Site Selection Criteria
1	BER_0-8_L	Located on Bear Creek
11	ELC_1-4_L	Located on one of the smaller channels, such as Elder Creek or Dear Creek
14	FHR_0-6_L	Located on the Feather River
32	GEO_9-3_L	Located on Georgiana Slough
38	LAR_7-3_R	Located on the American River
43	SAC_23-2_L	In the Sacramento River Delta downstream of Courtland, California (downstream of River Mile[1] 34.0)
57	SAC_63-0_R	In the Sacramento River between Verona and Courtland, California (between River Miles[1] 80.0 to 34.0)
84	SAC_136-6_L	In the Sacramento River between Colusa and Verona, California (between River Miles[1] 140.0 to 80.0)
86	SAC_152-8_L	In the meander section of the Sacramento River North of Colusa, California (upstream of UNET River Mile[1] 140.0)
104	YOL_2-5_R	Located in one of the large project bypasses such as the Sutter or Yolo bypasses

Note:
[1]River miles specified in site selection criteria column refer to the Historic United States Geological Survey (USGS) River Miles.

6.1 The Hydrograph

When the hydrograph was selected as the input parameter to be varied for sensitivity analysis, velocity and duration were decreased and increased by 25 % without changing other parameters. As an example, Table 7 below shows the results for Reference Site 57. Results are also illustrated graphically in Figure 2.

Table 7. Hydrograph Sensitivity Analysis.

Base Values		25% Decrease		25% Increase	
Velocity (ft/s)	Time (Hours)	Velocity (ft/s)	Time (Hours)	Velocity (ft/s)	Time (Hours)
0.00	200	0.00	150	0.00	250.00
0.65	200	0.49	150	0.81	250.00
0.65	50	0.49	37.5	0.81	62.50
1.30	50	0.97	37.5	1.62	62.50

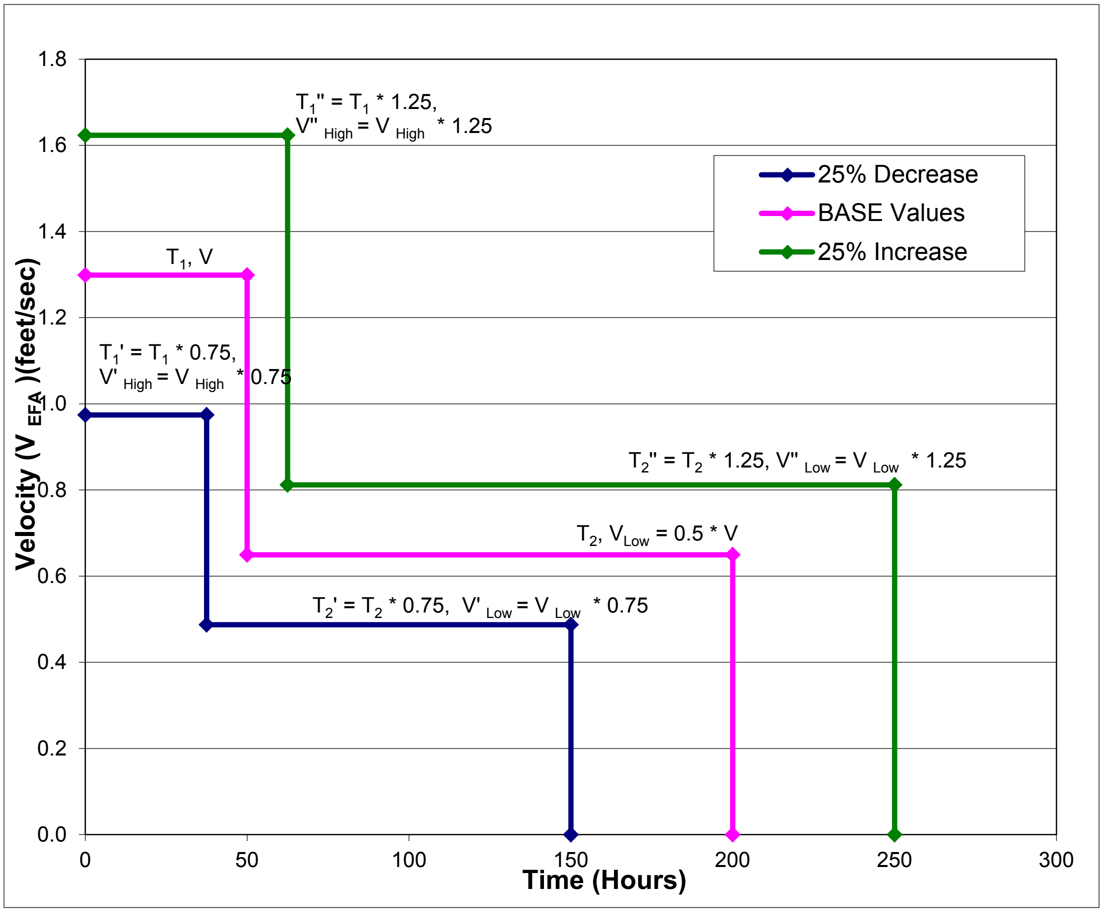

Figure 2. The Hydrograph Sensitivity Analysis.

Results of the hydrograph sensitivity analysis indicate no change in AEP for eight out of the ten selected sites when the velocity and duration were decreased by 25%. Sites, which had changes in AEP, resulted in 2% and 16% decreases in AEP. Similarly, there was no change in AEP for eight out of the ten selected sites when the velocity and duration were increased by 25%. Two sites which had changes in AEP exhibited a 30% increase in AEP.

Table 8 and Table 9 present the base AEP and the change in AEP when the velocity and duration were decreased and increased by 25% respectively for the 10 selected sites.

Table 8. Hydrograph Sensitivity Analysis Results for 25 Percent Decrease.

Reference No	Site ID	Base Value AEP in 2010 with Flood (Percent)	25 Percent Decrease AEP in 2010 with Flood (Percent)	AEP (Percent Change)
1	BER_0-8_L	20	20	0
11	ELC_1-4_L	50	50	0
14	FHR_0-6_L	4	4	0
32	GEO_9-3_L	10	10	0
38	**LAR_7-3_R**	**4**	**2**	**-2**
43	SAC_23-2_L	4	4	0
57	SAC_63-0_R	2	2	0
84	**SAC_136-6_L**	**20**	**4**	**-16**
86	SAC_152-8_L	50	50	0
104	YOL_2-5_R	4	4	0

Table 9. Hydrograph Sensitivity Analysis Results for 25 Percent Increase.

Reference No	Site ID	Base Value AEP in 2010 with Flood (Percent)	25 Percent Increase AEP in 2010 with Flood (Percent)	AEP (Percent Change)
1	**BER_0-8_L**	**20**	**50**	**+ 30**
11	ELC_1-4_L	50	50	0
14	FHR_0-6_L	4	4	0
32	GEO_9-3_L	10	10	0
38	LAR_7-3_R	4	4	0
43	SAC_23-2_L	4	4	0
57	SAC_63-0_R	2	2	0
84	**SAC_136-6_L**	**20**	**50**	**+30**
86	SAC_152-8_L	50	50	0
104	YOL_2-5_R	4	4	0

6.2 Placement of the Standard Levee Prism

Sensitivity analysis was also performed by varying the placement of the standard levee prism. Due to physical characteristics of the placement of levee prism, The project team determined that the placement would be aligned with a physical levee point, rather than a placement relative to numerically increased or decreased amount.

The base condition AEP is estimated by placing the standard levee prism landside hinge point to be aligned with the levee landside slope. There are two viable directions for moving the standard levee prism toward the levee's waterside, or toward landside for sensitivity analysis:

- Waterside shift. The waterside hinge point is aligned with the levee waterside slope. Due to the impractical nature of this placement (as it would likely "over predict" vulnerability to erosion), sensitivity analysis with this placement was not performed. Instead, the center of the levee prism was aligned with the center of the levee crown.
- Landside shift. Landside shift of the prism is not practical; sensitivity of landside shift was not analyzed.

Figure 3 shows the levee prism at the center of levee, landside levee slope, and waterside levee slope.

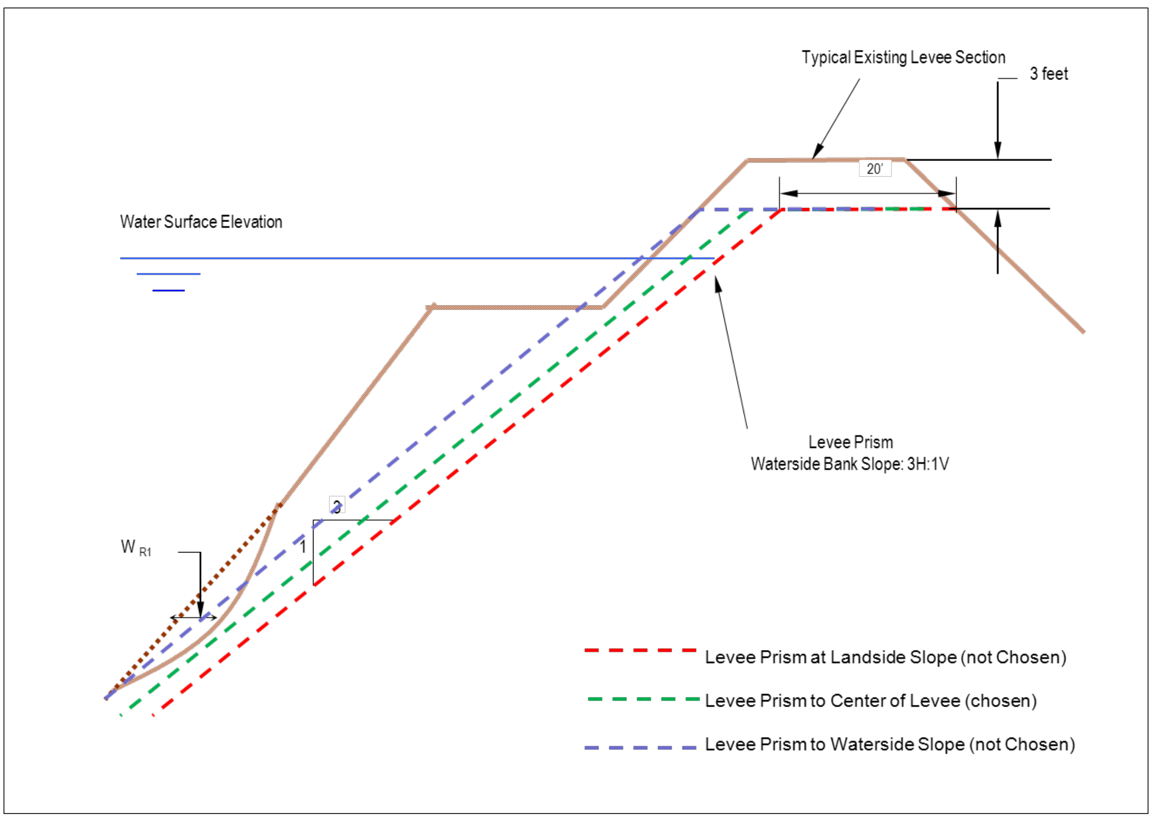

Figure 3. Placement of Standard Levee Prism Sensitive Analysis.

6.2.1 Waterside Shift Levee Prism to the Center of the Levee

This analysis was performed under 2010 project conditions both without and with a flood.

There was no change in AEP for seven of the 10 selected sites when the levee prism was placed at the center of the levee under 2010 project conditions without flood. Three sites had a change in AEP, resulting in an average 40% increase in AEP.

Similarly, there was no change in AEP for six out of the 10 selected sites when the levee prism was placed at the center of the levee under 2010 project conditions with flood. However, three out of the four sites had an average 30% increase in AEP while the remaining site had a nominal increase of 6%.

Table 10 and Table 11 present the AEP and the change in AEP when the levee prism is placed at the center of the levee under 2010 project conditions both without and with flood for the 10 selected sites.

Table 10. Placement of Standard Levee Prism, Parameter Sensitivity Analysis at Center of Levee Without Flood Results.

Reference No	Site ID	Base Values (Percent)	At Center of Levee (Percent)	AEP (Percent Change)
		AEP in 2010 without Flood	AEP in 2010 without Flood	
1	**BER_0-8_L**	**20**	**50**	**+30**
11	ELC_1-4_L	20	20	0
14	FHR_0-6_L	4	4	0
32	**GEO_9-3_L**	**10**	**50**	**+40**
38	LAR_7-3_R	1	1	0
43	SAC_23-2_L	4	4	0
57	SAC_63-0_R	2	2	0
84	**SAC_136-6_L**	**4**	**50**	**+46**
86	SAC_152-8_L	50	50	0
104	YOL_2-5_R	4	4	0

Table 11. Placement of the Standard Levee Prism, Parameter Sensitivity Analysis At Center Of Levee With Flood Results.

Reference No	Site ID	Base Values (Percent)	At Center of Levee (Percent)	AEP (Percent Change)
		AEP in 2010 with Flood	AEP in 2010 with Flood	
1	**BER_0-8_L**	**20**	**50**	**+30**
11	ELC_1-4_L	50	50	0
14	FHR_0-6_L	4	4	0
32	**GEO_9-3_L**	**10**	**50**	**+40**

Table 11. Placement of the Standard Levee Prism, Parameter Sensitivity Analysis At Center Of Levee With Flood Results.				
Reference No	**Site ID**	**Base Values (Percent)**	**At Center of Levee (Percent)**	**AEP (Percent Change)**
		AEP in 2010 with Flood	**AEP in 2010 with Flood**	
38	LAR_7-3_R	4	4	0
43	**SAC_23-2_L**	**4**	**10**	**+6**
57	SAC_63-0_R	2	2	0
84	**SAC_136-6_L**	**20**	**50**	**+30**
86	SAC_152-8_L	50	50	0
104	YOL_2-5_R	4	4	0

6.3 Erosion Rate Versus Velocity

Sensitivity analysis was performed by increasing and decreasing the erosion rate (R_E) input parameter by 25% while the velocity remained unchanged. The erosion rate was based on the erosion screening process developed using ULE Program data in the Central Valley. Table 12 presents the R_E for a 25% decrease and increase in erosion rates.

Table 12. Erosion Rate Versus Velocity Parameter Sensitivity Analysis.									
Velocity (V_{EFA}) (ft/s)	**Erosion Rate (feet/hour)**								
	25 Percent Decrease			**Base Values**			**25 Percent Increase**		
	Silt	**Sand**	**Clay**	**Silt**	**Sand**	**Clay**	**Silt**	**Sand**	**Clay**
0.5	0.00225	0.00165	0.001125	0.003	0.0022	0.0015	0.0038	0.0028	0.0019
1	0.015	0.00675	0.00375	0.02	0.009	0.005	0.0250	0.0113	0.0063
1.5	0.04425	0.01575	0.00675	0.059	0.021	0.009	0.0738	0.0263	0.0113
2	0.096	0.02775	0.0105	0.128	0.037	0.014	0.1600	0.0463	0.0175
2.5	0.1755	0.04425	0.015	0.234	0.059	0.02	0.2925	0.0738	0.0250
3	0.2865	0.06375	0.0195	0.382	0.085	0.026	0.4775	0.1063	0.0325
3.5	0.435	0.08775	0.0255	0.58	0.117	0.034	0.7250	0.1463	0.0425
4	0.62475	0.11475	0.0315	0.833	0.153	0.042	1.0413	0.1913	0.0525
4.5	0.85875	0.14625	0.03825	1.145	0.195	0.051	1.4313	0.2438	0.0638
5	1.1415	0.1815	0.045	1.522	0.242	0.06	1.9025	0.3025	0.0750
5.5	1.4775	0.2205	0.0525	1.97	0.294	0.07	2.4625	0.3675	0.0875
6	1.86975	0.264	0.06075	2.493	0.352	0.081	3.1163	0.4400	0.1013

Table 12. Erosion Rate Versus Velocity Parameter Sensitivity Analysis.

Velocity (V_{EFA}) (ft/s)	Erosion Rate (feet/hour)								
	25 Percent Decrease			Base Values			25 Percent Increase		
	Silt	Sand	Clay	Silt	Sand	Clay	Silt	Sand	Clay
7	2.8365	0.3615	0.07725	3.782	0.482	0.103	4.7275	0.6025	0.1288
8	4.07025	0.4755	0.096	5.427	0.634	0.128	6.7838	0.7925	0.1600
9	5.59725	0.6045	0.11625	7.463	0.806	0.155	9.3288	1.0075	0.1938
10	7.44225	0.75	0.138	9.923	1	0.184	12.4038	1.2500	0.2300
11	9.63075	0.91125	0.1605	12.841	1.215	0.214	16.0513	1.5188	0.2675
12	12.186	1.089	0.1845	16.248	1.452	0.246	20.3100	1.8150	0.3075

The results of erosion rate verses velocity sensitivity analysis indicated that, there was no change in AEP for 9 of the 10 selected sites when the erosion rate was decreased by 25%. Similarly, when the erosion rate was increased by 25% none of the 10 selected sites had a change in AEP.

Table 13 and Table 14 present the AEP and change in AEP when the erosion rate was decreased and increased by 25% at the 10 selected sites.

Table 13. Erosion Rate Versus Velocity Sensitivity Analysis Results for 25 Percent Decrease.

Reference No	Site ID	25 Percent Decrease	Base Values (Percent)	AEP (Percent Change)
		AEP in 2010 with Flood	AEP in 2010 with Flood	
1	BER_0-8_L	20	20	0
11	ELC_1-4_L	50	50	0
14	FHR_0-6_L	4	4	0
32	GEO_9-3_L	10	10	0
38	LAR_7-3_R	4	4	0
43	SAC_23-2_L	4	4	0
57	SAC_63-0_R	2	2	0
84	**SAC_136-6_L**	**10**	**20**	**-10**
86	SAC_152-8_L	50	50	0
104	YOL_2-5_R	4	4	0

Table 14. Erosion Rate Versus Velocity Sensitivity Analysis Results for 25 Percent Increase.

Reference No	Site ID	Base Values (Percent)	25 Percent Increase	AEP (Percent Change)
		AEP in 2010 with Flood	AEP in 2010 with Flood	
1	BER_0-8_L	20	20	0
11	ELC_1-4_L	50	50	0
14	FHR_0-6_L	4	4	0
32	GEO_9-3_L	10	10	0
38	LAR_7-3_R	4	4	0
43	SAC_23-2_L	4	4	0
57	SAC_63-0_R	2	2	0
84	SAC_136-6_L	20	20	0
86	SAC_152-8_L	50	50	0
104	YOL_2-5_R	4	4	0

6.4 Relationship Between Erosion Width and Probability of Failure

Sensitivity analysis was then performed by increasing and decreasing the ratio of erosion width (W_R) over effective levee width (W_E) by 25% without changing the estimated probability ranking. This analysis was performed under 2010 project conditions both without and with flood. Table 15 and Table 16 below show estimated probability for a 25% decrease and increase in ratio of W_R over effective W_E. (Table 2 and Table 3, provided earlier in this report, show the estimated probability for a ratio of erosion width over effective levee width during AEP.)

Table 15. Sensitivity Analysis, Relationship Between Erosion Width and Probability of Failure by 25 Percent Decrease.

Erosion Outside of Levee Prism and AEP	
Ratio of W_R/W_E	**AEP**
< 0.75%	0.005, or 0.5%
0.75% to 3.75%	0.01, or 1%
3.75% to 7.5%	0.02, or 2%
> 7.5%	0.04, or 4%
Erosion Within Levee Prism and AEP	
Ratio of W_R/W_E	**AEP**
0.75% to 11.25%	0.04, or 4%
11.25% to 15.0%	0.1, or 10%
15.0% to 18.75%	0.2, or 20%
> 18.75%	0.5, or 50%

Table 16. Sensitivity Analysis, Relationship Between Erosion Width and Probability of Failure by 25 Percent Increase.	
Erosion Outside of Levee Prism and AEP	
Ratio of W_R/W_E	**AEP**
< 1.25%	0.005, or 0.5%
1.25% to 6.25%	0.01, or 1%
6.25% to 12.5%	0.02, or 2%
> 12.5%	0.04, or 4%
Erosion Within Levee Prism and AEP	
Ratio of W_R/W_E	**AEP**
1.25% to 18.75%	0.04, or 4%
18.75% to 25%	0.1, or 10%
25% to 31.25%	0.2, or 20%
> 31.25%	0.5, or 50%

6.4.1 Decreasing W_R/W_E by 25%

There was no change in AEP for 7 out of the 10 selected sites when the ratio of W_R/W_E was decreased by 25% under 2010 project conditions without a flood. Two out of the three sites had a change in AEP, resulting in a 10% decrease in AEP while the remaining site had a 6% decrease in AEP.

Similarly, there was no change in AEP for six out of the 10 selected sites when the ratio of W_R/W_E was decreased by 25% under 2010 project conditions with flood. Two out of the four sites had a change in AEP, resulting in a 10% decrease in AEP while the remaining two sites had decreases of 30% and 6%.

Table 17 presents the AEP and change in AEP when the ratio of W_R over effective W_E was decreased by 25% under 2010 project conditions both without and with flood for the 10 selected sites.

6.4.2 Increasing W_R/W_E by 25%

There was no change in AEP for 7 of the 10 selected sites when the ratio of W_R/W_E was increased by 25% under 2010 project conditions without flood. Two of the three sites had a change in AEP, resulting in a 30% increase in AEP while the remaining site had a 10% increase in AEP.

Similarly, there was no change in AEP for 6 of the 10 selected sites when the ratio of W_R/W_E was increased by 25% under 2010 project conditions with flood. Two of the four sites had a change in AEP, resulting in a 30% increase in AEP while the remaining two sites had increases of 10% and 2%.

Table 17. Erosion Width over Effective Levee Width, Sensitivity Analysis Results for 25 Percent Decrease.

Reference No	Site ID	25 Percent Decrease		Base Values (Percent)		AEP Percent Change	
		AEP in 2010 without Flood	AEP in 2010 with Flood	AEP in 2010 without Flood	AEP in 2010 with Flood	AEP in 2010 without Flood	AEP in 2010 with Flood
1	**BER_0-8_L**	**10**	**10**	**20**	**20**	**-10**	**-10**
11	**ELC_1-4_L**	**10**	**20**	**20**	**50**	**-10**	**-30**
14	FHR_0-6_L	4	4	4	4	0	0
32	**GEO_9-3_L**	**4**	**4**	**10**	**10**	**-6**	**-6**
38	LAR_7-3_R	0.5	4	1	4	0	0
43	SAC_23-2_L	4	4	4	4	0	0
57	SAC_63-0_R	2	2	2	2	0	0
84	**SAC_136-6_L**	**4**	**10**	**4**	**20**	**0**	**-10**
86	SAC_152-8_L	50	50	50	50	0	0
104	YOL_2-5_R	4	4	4	4	0	0

Table 18 presents the AEP and change in AEP when the ratio of W_R over effective W_E was increased by 25% under 2010 project conditions both without and with a flood at the 10 selected sites.

Table 18. Erosion Width over Effective Levee Width Sensitivity Analysis Results for 25 Percent Increase.

Reference No	Site ID	Base Values (Percent)		25 Percent Increase		AEP Percent Change	
		AEP in 2010 without Flood	AEP in 2010 with Flood	AEP in 2010 without Flood	AEP in 2010 with Flood	AEP in 2010 without Flood	AEP in 2010 with Flood
1	**BER_0-8_L**	**20**	**20**	**50**	**50**	**+30**	**+30**
11	**ELC_1-4_L**	**20**	**50**	**50**	**50**	**+30**	**0**
14	FHR_0-6_L	4	4	4	4	0	0
32	**GEO_9-3_L**	**10**	**10**	**20**	**20**	**+10**	**+10**
38	LAR_7-3_R	1	4	0.5	4	0	0
43	SAC_23-2_L	4	4	4	4	0	0
57	SAC_63-0_R	2	2	2	4	0	**2**
84	**SAC_136-6_L**	**4**	**20**	**4**	**50**	**0**	**+30**
86	SAC_152-8_L	50	50	50	50	0	0
104	YOL_2-5_R	4	4	4	4		0

7.0 UNCERTAINTY AND LIMITATIONS

7.1 Uncertainty

This report is based upon the JV's interpretation of available information and certain key assumptions. Evaluation results are conditioned upon these assumptions, and are defined below.

Topographic data used in this evaluation was based on the light detection and ranging (LiDAR) data and bathymetry data collected from DWR's Urban Levee Geotechnical Evaluations (ULE) Program. These topographic data were collected per ULE Program specifications. Bathymetry data were not available for all sites within the project reaches. Whenever a discrepancy was found in data provided by others, the cross section of each erosion site was updated in accordance with the site conditions observed during the field visits. Data presented in this report are the best available information and are time-sensitive, in that they apply only to locations and conditions existing at the time of LiDAR survey and preparation of this report. These topographic data should not be applied to any other projects in or near the area of study; nor should they be applied under future conditions without appropriate verification. Topographic data should not to be used as the basis for design and construction.

Where bathymetry is not available, bank and channel geometry were estimated below the water surface using the best available information. This information includes the available hydraulic model cross sections (such as a UNET model), an approximated depth of water and an approximated channel slope.

Placement of the standard levee prism was based on conservatism and engineering judgment. Prism placement on landside slopes allows erosion assessment for the entire levee width. Prism placement 3 feet below crest is based on a typical levee cross section and design freeboard along the Sacramento River. Some exceptions were considered for the sites at Deer Creek, Elder Creek and Georgiana Slough (see Section 3.3) due to their unique circumstances.

Riverine hydrologic and hydraulic data were obtained from other available studies. At most sites, velocities were obtained from the 2007 Ayres and Associates' *Field Reconnaissance Report* (Ayres, 2007). This report presented mean channel velocities were using a USACE UNET hydraulic model based on the 100-year discharge, where available. For this report, channel velocities at some erosion sites were adjusted based on conditions observed in the field. These velocities cannot be used as the basis for design or construction.

Field observation and assessment are engineering judgments based on a combination of an individual's observations and available information. Site conditions varied during field observation and could change after field observation.

The erosion rates of silt, sand and clay levee material were developed from the ULE Program dataset for California's Central Valley. Soil sample and lab testing information, although limited, are the best available information.

To provide a consistent impact evaluation, a high-flood event was assumed. The velocity and duration of this high-flood event are based on hydrographs of past flood events in the Central Valley. These typical velocities and durations do not represent any specific flood event.

7.2 Limitation

This report was prepared by the JV in a manner consistent with the level of care and skill ordinarily exercised by professional engineers in the geographic area of study, based upon the information available at the time of the project. The JV provides no other warranties, express or implied, concerning the contents of this paper, which was prepared under the technical direction of a registered professional engineer.

This evaluation is not design-level, but of a more general nature, and similar to estimates found in a PL94-99-type *Project Information Report* analysis or a pre-feasibility phase analysis. AEP estimates are general in nature, and in this case are further confined to the seven pre-defined choices made by USACE.

Evaluation data presents the best estimated probability of erosion damage in any given year. Evaluations provide a numerical value (in general classes) and document the rationale for these decisions.

8.0 REFERENCES

Ayres Associates. 2007. *Field Reconnaissance Report of Bank Erosion Sites and Site Priority Ranking.* Sacramento River Flood Control Levees, Tributaries and Distributaries, Sacramento River Bank Protection Project. Prepared for USACE.

USACE. 2002. Sacramento and San Joaquin River Basins Comprehensive Study, Sacramento River Basin UNET Model. April.

USACE. 2010. Levee Survey data Collected during 2010 annual erosion inventory in June-July 2010.

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ENCLOSURE 2

Supporting Data

Impact Area Number (From Comp Study)	Name/Location of Impact Area	Index Point Location Used for Economic Analysis	Top of Levee (TOL) Elevation	Adjusted Without-Project Fragility Curve (AEP Level of More Critical Erosion Sites)		Adjusted Without-Project Fragility Curve (AEP Level of Less Critical Erosion Sites)		With-Project Fragility Curve (AEP Level from Comprehensive Study WO Analysis/Other Current Study Analysis)	
				Elevation	P(f)	Elevation	P(f)	Elevation	P(f)
15	Yolo	Knights Landing Ridge Cut LM 3.02R	38.86	26.41	0.90	30.90	0.01	30.90	0.15
				30.90	0.95	32.40	0.02	32.40	0.50
				32.40	0.97	34.90	0.10	34.90	0.85
				34.90	0.99	38.70	0.15		
				AEP = .500		AEP = .010		AEP = .074	
55	Ryer Island	Sutter Slough RM 22.23R	25.35	10.40	0.05	10.40	0.05	10.40	0.15
				10.90	0.10	10.90	0.15	10.90	0.50
				11.10	0.55	11.40	0.25	11.40	0.85
						25.30	0.40		
				AEP = .100		AEP = .040		AEP = .124	
61	Hastings Tract	Cache Slough RM 21R	17.70	6.35	0.70	None		8.20	0.15
				8.20	0.75			8.70	0.50
				8.70	0.80			9.20	0.85
				9.20	0.99				
				AEP = .500				AEP = .329	
42	Clarksburg	Sutter Slough RM 25.23R	22.86	10.90	0.02	10.90	0.00	10.90	0.15
				13.90	0.06	13.90	0.02	13.90	0.50
				16.90	0.20	16.90	0.03	16.90	0.85
						21.80	0.10		
				AEP = .020		AEP = .005		AEP = .131	
53	Tyler Island	Georgiana Slough RM .25L	10.53	6.50	0.05	6.50	0.02	6.50	0.50
				6.90	0.17	6.90	0.03	6.90	0.85
				7.10	0.35	10.40	0.08		
				AEP = .200		AEP = .040		AEP = .805	
13 and 14	Knights Landing	Sacramento River RM 90R	44.43	35.50	0.05	35.50	0.02	35.50	0.15
				38.00	0.25	38.00	0.03	38.00	0.50
				40.50	0.40	40.50	0.07	40.50	0.85
				AEP = .040		AEP = .020		AEP = .070	
50	Grand Island	Sacramento River RM 14.75R	22.85	7.30	0.05	7.30	0.05	7.30	0.15
				7.80	0.10	7.80	0.10	7.80	0.50
				8.30	0.20	8.30	0.20	8.30	0.85
				22.70	0.60	22.70	0.60		
				AEP = .040		AEP = .040		AEP = .108	
49	Sutter Island	Sutter Slough RM 23.73L	25.20	9.05	0.75	11.80	0.02	11.80	0.15
				11.80	0.80	12.30	0.05	12.30	0.50
				12.30	0.85	12.80	0.15	12.80	0.85
				12.80	0.99	25.20	0.75		
				AEP = .500		AEP = .040		AEP = .103	
16	Woodland	Yolo Bypass LM 48.84R	32.78	24.80	0.01	24.80	0.01	24.80	0.15
				30.30	0.25	30.30	0.03	30.30	0.50
				32.70	0.50	32.70	0.08	32.70	0.85
				AEP = .040		AEP = .010		AEP = .090	
17	Davis	Putah Creek	46.23	42.80	0.15	42.80	0.15	42.80	0.15
				43.80	0.50	43.80	0.50	43.80	0.50
				45.30	0.85	45.30	0.85	45.30	0.85
				AEP = .040		AEP = .040		AEP = .040	

37	Arden	American River RM 11.33R	58.60	52.60	0.25	52.60	0.25	52.60	0.05
				54.60	0.35	54.60	0.35	54.60	0.11
				56.60	0.43	56.60	0.43	56.60	0.43
				58.60	0.93	58.60	0.93	58.60	0.93
				AEP = .010		AEP = .010		AEP = .010	
30	Rio Oso	Feather River RM 7.17R	52.40	42.30	0.50	43.10	0.05	43.10	0.15
				43.10	0.65	46.00	0.20	46.00	0.50
				46.00	0.85	49.50	0.50	49.50	0.85
				49.50	0.99				
				AEP = .200		AEP = .040		AEP = .086	
54	Brannan Andrus	Georgiana Slough RM .75R	10.89	6.70	0.02	6.70	0.02	6.20	0.15
				7.20	0.05	7.20	0.05	6.70	0.50
				10.80	0.65	10.80	0.65	7.20	0.85
				AEP = .040		AEP = .040		AEP = .671	
46	Merritt Island	Sacramento River RM 41R	26.21	17.30	0.05	N/A		17.30	0.15
				19.80	0.10			19.80	0.50
				22.30	0.15			22.30	0.85
				26.20	0.35				
				AEP = .040		AEP = .005		AEP = .156	
39	Southport	Sacramento River RM 52.75R	39.00	26.45	0.20	26.45	0.20	26.45	0.04
				27.00	0.30	27.00	0.30	27.00	0.04
				35.00	0.40	35.00	0.40	35.00	0.17
				37.00	0.45	37.00	0.45	37.00	0.27
				39.00	0.75	39.00	0.75	39.00	0.43
				AEP = .040		AEP = .040		AEP = .011	
40	Sacramento	Sacramento River RM 51L	31.50	24.00	0.30	24.00	0.15	25.40	0.10
				25.40	0.65	25.40	0.25	27.40	0.23
				27.40	0.85	27.40	0.50	29.40	0.49
				29.40	0.90	29.40	0.75	31.40	0.73
				31.40	0.99	31.40	0.85		
				AEP = .040		AEP = .020		AEP = .008	
38	West Sacramento	Sacramento River RM 59.99R	40.00	32.00	0.65	32.00	0.25	32.00	0.02
				34.00	0.85	34.00	0.40	34.00	0.09
				36.00	0.90	36.00	0.50	36.00	0.37
				38.00	0.95	38.00	0.75	38.00	0.81
				40.00	0.99	40.00	0.99	40.00	0.99
				AEP = .040		AEP = .020		AEP = .009	
35	Elkhorn	Sacramento River RM 76.75R	40.12	31.20	0.01	31.20	0.01	28.20	0.15
				34.20	0.02	34.20	0.02	31.20	0.50
				40.10	0.04	40.10	0.04	34.20	0.85
				AEP = .040		AEP = .040		AEP = .500	
36	Natomas	Sacramento River RM 79.00L	44.40	36.40	0.02	36.40	0.02	36.40	0.01
				39.40	0.04	39.40	0.04	39.40	0.01
				41.40	0.05	41.40	0.05	41.40	0.05
				44.39	0.12	44.39	0.12	44.39	0.12
				AEP = .010		AEP = .010		AEP = .007	
11 and 34	South Sutter	Sacramento River RM 86.50L	42.59	33.80	0.60	33.80	0.02	33.80	0.15
				36.30	0.95	36.30	0.05	36.30	0.50
				38.80	0.99	38.80	0.15	38.80	0.85
						42.70	0.35		
				AEP = .500		AEP = .040		AEP = .254	
				45.00	0.02	45.00	0.02	45.00	0.33

10	Grimes	Sacramento River RM 119.75R	55.51	46.50	0.03	46.50	0.03	46.50	0.50
				49.50	0.05	49.50	0.05	49.50	0.85
				55.40	0.35	55.40	0.35		
				AEP = .040		AEP = .040		AEP = .533	
32	North Sutter	Sutter Bypass LM 88.60	58.60	50.60	0.10	50.60	0.10	50.60	0.15
				56.10	0.40	56.10	0.40	56.10	0.50
				58.50	0.85	58.50	0.85	58.50	0.85
				AEP = .040		AEP = .040		AEP = .050	
27	Linda	Yuba River LM 5.7L	94.10	88.00	0.08	88.00	0.08	88.00	0.04
				90.00	0.30	90.00	0.30	90.00	0.24
				92.00	0.87	92.00	0.87	92.00	0.78
				94.00	1.00	94.00	1.00	94.00	1.00
				AEP = .010		AEP = .010		AEP = .008	
5	Butte Basin	Sacramento River RM 183.50L	112.86	111.00	0.02	N/A		None	
				111.63	0.05				
				AEP = .500				AEP = .281	

ENCLOSURE 3

Depth-Percent Damage Curves

ENCLOSURE 2

Depth-Percent Damage Curves – Structures and Contents

Table 1

C-RET1		
Commercial Retail 1-story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	42.71
1	21.73	79.83
1.5	26	94.79
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 2

C-RET2		
Commercial Retail 2-story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	20.49
1	15.26	38.31
1.5	17.1	49.61
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 3

C-DEAL1		
Full Service Auto Dealership 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	5.75
-0.5	3.5	5.81
0	7	5.81
0.5	14.4	41.07
1	21.73	80.26
1.5	26	97.18
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 4

C-DEAL2		
Full Service Auto Dealership 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	2.76
-0.5	2.5	2.79
0	5	2.79
0.5	10.1	19.71
1	15.26	38.52
1.5	17.1	50.86
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 5

C-FURN1		
Furniture Store 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	89.48
1	21.73	98.2
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 6

C-FURN2		
Furniture Store 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	42.94
1	15.26	47.13
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 7

C-HOS1		
Hospital 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	50
1	21.73	75.49
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 8

C-HOS2		
Hospital 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	24
1	15.26	36.23
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 9

C-AUTO1		
Commercial Auto Sales 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	48.39
1	21.73	96.78
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 10

C-AUTO2		
Commercial Auto Sales 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	42.89
1	15.26	46.44
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 11

C-HOTEL1		
Hotel 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	47.36
1	21.73	91.34
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 12

C-HOTEL2		
Hotel 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	22.73
1	15.26	43.83
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 13

C-FOOD1		
Commercial Food-Retail 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0.5
0.5	14.4	56.98
1	21.73	78.33
1.5	26	94.47
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 14

C-FOOD2		
Commercial Food-Retail 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0.24
0.5	10.1	27.35
1	15.26	37.59
1.5	17.1	49.44
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 15

C-RESTFF1		
Commercial Fast Food Rest 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	45.1
1	21.73	87.8
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 16

C-RESTFF2		
Commercial Fast Food Rest 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	21.64
1	15.26	42.14
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 17

C-GROC1		
Commercial Grocery Store 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	61.04
1	21.73	87.33
1.5	26	94.38
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 18

C-GROC2		
Commercial Grocery Store 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	29.29
1	15.26	41.91
1.5	17.1	49.39
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 19

C-MED1		
Commercial Medical 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	50
1	21.73	75.49
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 20

C-MED2		
Commercial Medical 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	24
1	15.26	36.23
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 21

C-OFF1		
Commercial Office 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	48.39
1	21.73	96.78
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 22

C-OFF2		
Commercial Office 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	42.89
1	15.26	46.44
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 23

C-SHOP1		
Commercial Shopping Center 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	76.45
1	21.73	95.92
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 24

C-SHOP2		
Commercial Shopping Center 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	36.69
1	15.26	46.03
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 25

C-REST1		
Commercial Restaurant 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	47.36
1	21.73	91.34
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 26

C-REST2		
Commercial Restaurant 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	22.73
1	15.26	43.83
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 27

C-SERV1		
Commercial Service-Auto 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	9.91
-0.5	3.5	10
0	7	10
0.5	14.4	38.69
1	21.73	73.51
1.5	26	97.44
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 28

C-SERV1		
Commercial Service-Auto 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	4.75
-0.5	2.5	4.8
0	5	4.8
0.5	10.1	18.57
1	15.26	35.28
1.5	17.1	50.99
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 29

I-LT1		
Industrial Light 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0.19
0.5	14.4	45.36
1	21.73	87.64
1.5	26	92.79
2	30.19	96.39
3	31.22	98.97
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 30

I-LT2		
Industrial Light 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0.19
0.5	10.1	21.77
1	15.26	42.06
1.5	17.1	48.56
2	18.88	53.95
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 31

I-HV1		
Industrial Heavy Manufacture 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	12.18
1	21.73	32.69
1.5	26	53.81
2	30.19	69.95
3	31.22	77.48
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 32

I-HV2		
Industrial Heavy Manufacture 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	5.85
1	15.26	15.69
1.5	17.1	28.16
2	18.88	39.15
3	21.48	43.37
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 33

I-WH1		
Industrial Warehouse 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	41.32
1	21.73	84.19
1.5	26	94.42
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 34

I-WH2		
Industrial Warehouse 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	19.83
1	15.26	40.4
1.5	17.1	49.41
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 35

P-CH1		
Public Church 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	47.33
1	21.73	73.35
1.5	26	83.86
2	30.19	98.82
3	31.22	98.82
4	32.44	98.82
5	32.44	98.82
6	39.82	98.82
7	42.76	98.82
8	51.72	98.82
9	53.1	98.82
10	54.09	98.82
11	61.78	98.82
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 36

P-CH2		
Public Church 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	22.71
1	15.26	35.2
1.5	17.1	43.88
2	18.88	55.31
3	21.48	55.31
4	22.8	55.31
5	22.8	55.31
6	24.05	55.31
7	26.1	55.31
8	40.4	66.08
9	43.25	66.08
10	46.2	66.08
11	46.2	68.47
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 37

P-GOV1		
Public Government Building 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	48.39
1	21.73	96.78
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 38

P-GOV2		
Public Government Building 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	40.87
1	15.26	45.43
1.5	17.1	51.23
2	18.88	55.88
3	21.48	55.88
4	22.8	55.88
5	22.8	55.88
6	24.05	55.88
7	26.1	55.88
8	40.4	68.08
9	43.25	68.08
10	46.2	68.08
11	46.2	69.4
12	49.05	100
13	49.05	100
14	55.16	100
15	80.05	100

Table 39

P-REC1		
Public Recreation/Assembly 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	50
1	21.73	97.95
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 40

P-REC2		
Public Recreation/Assembly 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	24
1	15.26	47.01
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 41

P-SCH1		
Public and Private Schools 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	50
1	21.73	87.78
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 42

P-SCH2		
Public and Private Schools 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	24
1	15.26	42.12
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 43

FARM		
Farm Buildings Including Primary RES		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	29.67
1	21.73	56.23
1.5	26	69.84
2	30.19	93.46
3	31.22	99.58
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 44

SFRB1		
Single Family Residential 1-story W/Basement		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	5.2	5.7
-3	9	8
-2	13.8	10.5
-1	19.4	13.2
-0.5	22.5	14.6
0	25.5	16
0.5	28.8	17.5
1	32	18.9
1.5	35.4	20.4
2	38.7	21.8
3	45.5	24.7
4	52.2	27.4
5	58.6	30
6	64.5	32.4
7	69.8	34.5
8	74.2	36.3
9	77.7	37.7
10	80.1	38.6
11	81.1	39.1
12	81.1	39.1
13	81.1	39.1
14	81.1	39.1
15	81.1	39.1

Table 45

SFRB2		
Single Family Residential 2-story W/Basement		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	4.7	5.2
-3	7.2	6.8
-2	10.2	8.4
-1	13.9	10.1
-0.5	15.9	11
0	17.9	11.9
0.5	20.1	12.9
1	22.3	13.8
1.5	24.7	14.8
2	27	15.7
3	31.9	17.7
4	36.9	19.8
5	41.9	22
6	46.9	24.3
7	51.8	26.7
8	56.4	29.1
9	60.8	31.7
10	64.8	34.4
11	68.4	37.2
12	71.4	40
13	73.7	43
14	75.4	46.1
15	76.4	49.3

Table 46

SFRBS		
Single Family Residential Split-Level W/Basement		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	4.7	3.8
-3	7.2	5.4
-2	10.4	7.3
-1	14.2	9.4
-0.5	16.4	10.5
0	18.5	11.6
0.5	20.9	12.7
1	23.2	13.8
1.5	25.7	15
2	28.2	16.1
3	33.4	18.2
4	38.6	20.2
5	43.8	22.1
6	48.8	23.6
7	53.5	24.9
8	57.8	25.8
9	61.6	26.3
10	64.8	26.3
11	67.2	26.3
12	68.8	26.3
13	69.3	26.3
14	69.3	26.3
15	69.3	26.3

Table 47

SFR1		
Single Family Residential 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	2.5	2.4
-0.5	8	5.3
0	13.4	8.1
0.5	18.4	10.7
1	23.3	13.3
1.5	27.7	15.6
2	32.1	17.9
3	40.1	22
4	47.1	25.7
5	53.2	28.8
6	58.6	31.5
7	63.2	33.8
8	67.2	35.7
9	70.5	37.2
10	73.2	38.4
11	75.4	39.2
12	77.2	39.7
13	78.5	40
14	79.5	40
15	80.2	40

Table 48

SFR2		
Single Family Residential 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	3	1
-0.5	6.2	3
0	9.3	5
0.5	12.3	6.9
1	15.2	8.7
1.5	18.1	10.5
2	20.9	12.2
3	26.3	15.5
4	31.4	18.5
5	36.2	21.3
6	40.7	23.9
7	44.9	26.3
8	48.8	28.4
9	52.4	30.3
10	55.7	32
11	58.7	33.4
12	61.4	34.7
13	63.8	35.6
14	65.9	36.4
15	67.7	36.9

Table 49

SFRS		
Single Family Residential Split-Level		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	6.4	2.2
-0.5	6.8	2.6
0	7.2	2.9
0.5	8.3	3.8
1	9.4	4.7
1.5	11.2	6.1
2	12.9	7.5
3	17.4	11.1
4	22.8	15.3
5	28.9	20.1
6	35.5	25.2
7	42.3	30.5
8	49.2	35.7
9	56.1	40.9
10	62.6	45.8
11	68.6	50.2
12	73.9	54.1
13	78.4	57.2
14	81.7	59.4
15	83.8	60.5

Table 50

MFR1		
Multi-Family Residential 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	2.5	2.4
-0.5	8	5.3
0	13.4	8.1
0.5	18.4	10.7
1	23.3	13.3
1.5	27.7	15.6
2	32.1	17.9
3	40.1	22
4	47.1	25.7
5	53.2	28.8
6	58.6	31.5
7	63.2	33.8
8	67.2	35.7
9	70.5	37.2
10	73.2	38.4
11	75.4	39.2
12	77.2	39.7
13	78.5	40
14	79.5	40
15	80.2	40

Table 51

MFR2		
Multi-Family Residential 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	3	1
-0.5	6.2	3
0	9.3	5
0.5	12.3	6.9
1	15.2	8.7
1.5	18.1	10.5
2	20.9	12.2
3	26.3	15.5
4	31.4	18.5
5	36.2	21.3
6	40.7	23.9
7	44.9	26.3
8	48.8	28.4
9	52.4	30.3
10	55.7	32
11	58.7	33.4
12	61.4	34.7
13	63.8	35.6
14	65.9	36.4
15	67.7	36.9

Table 52

MH		
Mobile Home Single/Double		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	6.4	0
-0.5	7.3	0
0	9.9	0
0.5	43.4	85
1	44.7	85
1.5	45	90
2	45.7	95
3	96.5	99
4	96.5	99
5	96.5	99
6	96.5	99
7	96.5	99
8	96.5	99
9	96.5	99
10	96.5	99
11	96.5	99
12	96.5	99
13	96.5	99
14	96.5	99
15	96.5	99

Table 53

AUTO		
Automobiles		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	0	0
0	0	0
0.5	2.8	0
1	21.8	0
1.5	31.15	0
2	40.5	0
3	56.9	0
4	71.1	0
5	83.2	0
6	91.9	0
7	96.1	0
8	99.2	0
9	100	0
10	100	0
11	100	0
12	100	0
13	100	0
14	100	0
15	100	0

Sacramento River Bank Protection Project (SRBPP)
Median Square Footage and Median Structure Value Information
October 2010 Price Level

Impact Area	Median Sq Ft	Median Value
Butte Basin (5)	n/a	n/a
Grimes (10)	1,604	$89,736
Knight's Landing (13/14)	1,875	$122.730
Yolo (15)	n/a	n/a
Woodland (16)	n/a	n/a
Davis (17)	3,171	$510,277
Linda Yuba East (27)	1,287	$68,270
Rio Oso (30)	1,359	$83,621
North Sutter (32)	1,240	74,955
South Sutter (34)	3,205	$223,991
Elkhorn (35)	n/a	n/a
Natomas (36)	1,759	$141,167
Arden Rio Linda (37)	1,353	$103,900
West Sac (38)	1,489	$95,251
SouthPort (39)	2,192	$54,520
Sacramento 4of 4 (40)	1,474	$118,400
Clarksburg (42)	1,494	$100,102
Merritt island (46)	1,186	$76,967
Sutter Island (49)	1,690	$118,111
Grand Island (50)	n/a	n/a
Tyler Island (53)	1,818	$122,903
Brannan Andrus Isalnd (54)	1,592	$88,583
Ryer Island (55)	1,455	$94,424
Hastings Tract (61)	n/a	n/a

ENCLOSURE 4

Project Costs

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: Sacramento River Bank Protection Project - Economically Justified
PROJECT NO: P2 105606
LOCATION: Sacramento Valley - Various locations

DISTRICT: SPD South Pacific Division PREPARED: 6/16/2014
POC: CHIEF, COST ENGINEERING, xxx

This Estimate reflects the scope and schedule in report; Project X Major Rehabilitation Report June 2014

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
						Program Year (Budget EC): 2016 Effective Price Level Date: 1 OCT 15									
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	**TOTAL ($K)**	Spent Thru: **10/1/2013** ($K)	**TOTAL FIRST COST** ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	***B***	***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***				***M***	***N***	***O***
02	RELOCATIONS	$679	$149	22%	$828	3.5%	$702	$155	$857	$0	$857	7.1%	$753	$166	$918
06	FISH & WILDLIFE FACILITIES	$2,017	$444	22%	$2,461	3.5%	$2,087	$459	$2,546	$0	$2,546	6.6%	$2,225	$489	$2,714
11	LEVEES & FLOODWALLS	$4,182	$920	22%	$5,102	3.5%	$4,327	$952	$5,278	$0	$5,278	7.1%	$4,636	$1,020	$5,656
16	BANK STABILIZATION	$19,579	$4,307	22%	$23,886	3.5%	$20,256	$4,456	$24,712	$0	$24,712	5.8%	$21,436	$4,716	$26,152
	CONSTRUCTION ESTIMATE TOTALS:	$26,457	$5,821		$32,278	3.5%	$27,371	$6,022	$33,393	$0	$33,393	6.1%	$29,050	$6,391	$35,440
01	LANDS AND DAMAGES	$6,014	$2,815	47%	$8,829	3.5%	$6,222	$2,912	$9,134	$0	$9,134	4.1%	$6,478	$3,032	$9,510
30	PLANNING, ENGINEERING & DESIGN	$6,086	$1,339	22%	$7,425	5.7%	$6,431	$1,415	$7,846	$0	$7,846	9.0%	$7,008	$1,542	$8,550
31	CONSTRUCTION MANAGEMENT	$3,837	$844	22%	$4,681	5.7%	$4,054	$892	$4,946	$0	$4,946	12.3%	$4,553	$1,002	$5,555
18	CULTURAL RESOURCE PRESERVATION	$489	$0	0%	$489	0.0%	$489		$489	$0	$489	0.0%	$489	$0	$489
	PROJECT COST TOTALS:	$42,883	$10,818	25%	$53,701		$44,567	$11,240	**$55,808**	$0	**$55,319**	6.7%	$47,578	$11,966	$59,544

Mandatory by Regulation CHIEF, COST ENGINEERING, xxx

Mandatory by Regulation PROJECT MANAGER, xxx

Mandatory by Regulation CHIEF, REAL ESTATE, xxx

CHIEF, PLANNING,xxx

CHIEF, ENGINEERING, xxx

CHIEF, OPERATIONS, xxx

CHIEF, CONSTRUCTION, xxx

CHIEF, CONTRACTING,xxx

CHIEF, PM-PB, xxxx

CHIEF, DPM, xxx

ESTIMATED FEDERAL COST:	**65%**	**$38,704**
ESTIMATED NON-FEDERAL COST:	**35%**	**$20,840**
ESTIMATED TOTAL PROJECT COST:		**$59,544**

**** CONTRACT COST SUMMARY ****

PROJECT: Sacramento River Bank Protection Project - Economically Justified
LOCATION: Sacramento Valley - Various locations
This Estimate reflects the scope and schedule in report; Project X Major Rehabilitation Report June 2014

DISTRICT: SPD South Pacific Division PREPARED: 6/16/2014
POC: CHIEF, COST ENGINEERING, xxx

Civil Works Work Breakdown Structure		ESTIMATED COST	PROJECT FIRST COST (Constant Dollar Basis)	TOTAL PROJECT COST (FULLY FUNDED)

**** TOTAL PROJECT COST SUMMARY ****

			Estimate Prepared:			6/2/2014	Program Year (Budget EC):			2016					
			Effective Price Level:			10/1/2013	Effective Price Level Date:			1 OCT 15					
					RISK BASED										
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*		*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	CONTRACT 1														
16	BANK STABILIZATION	Butte Basin, Cherokee Canal 21.9 L	$1,106	$243	22%	$1,349	3.5%	$1,144	$252	$1,396	2017Q3	3.0%	$1,178	$259	$1,438
16	BANK STABILIZATION	Butte Basin, Sacramento River 152.8 L	$951	$209	22%	$1,160	3.5%	$984	$216	$1,200	2017Q3	3.0%	$1,013	$223	$1,236
16	BANK STABILIZATION	Butte Basin, Sacramento River 163 L	$1,495	$329	22%	$1,824	3.5%	$1,547	$340	$1,887	2017Q3	3.0%	$1,593	$350	$1,943
06	FISH & WILDLIFE FACILITIES	Butte Basin, Sacramento River 152.8 L	$55	$12	22%	$67	3.5%	$57	$13	$69	2017Q3	3.0%	$59	$13	$71
06	FISH & WILDLIFE FACILITIES	Butte Basin, Sacramento River 163 L	$179	$39	22%	$218	3.5%	$185	$41	$226	2017Q3	3.0%	$191	$42	$233
								$0							
	CONSTRUCTION ESTIMATE TOTALS:		$3,786	$833	22%	**$4,619**		$3,917	$862	$4,779			$4,034	$887	$4,921
01	LANDS AND DAMAGES	Butte Basin, Cherokee Canal 21.9 L	$152	$71	47%	$223	3.5%	$157	$74	$231	2016Q3	1.0%	$159	$74	$233
01	LANDS AND DAMAGES	Butte Basin, Sacramento River 152.8 L	$142	$66	47%	$208	3.5%	$147	$69	$216	2016Q3	1.0%	$148	$69	$218
01	LANDS AND DAMAGES	Butte Basin, Sacramento River 163 L	$568	$266	47%	$834	3.5%	$588	$275	$863	2016Q3	1.0%	$593	$278	$871
30	PLANNING, ENGINEERING & DESIGN														
2.5%	Project Management		$95	$21	22%	$116	5.7%	$100	$22	$122	2016Q3	1.9%	$102	$23	$125
2.0%	Planning & Environmental Compliance		$76	$17	22%	$93	5.7%	$80	$18	$98	2016Q3	1.9%	$82	$18	$100
8.5%	Engineering & Design		$322	$71	22%	$393	5.7%	$340	$75	$415	2016Q3	1.9%	$347	$76	$423
0.5%	Reviews, ATRs, IEPRs, VE		$19	$4	22%	$23	5.7%	$20	$4	$24	2016Q3	1.9%	$20	$5	$25
0.5%	schedule, risks)		$19	$4	22%	$23	5.7%	$20	$4	$24	2016Q3	1.9%	$20	$5	$25
2.0%	Contracting & Reprographics		$76	$17	22%	$93	5.7%	$80	$18	$98	2016Q3	1.9%	$82	$18	$100
3.0%	Engineering During Construction		$114	$25	22%	$139	5.7%	$120	$27	$147	2017Q3	5.9%	$128	$28	$156
2.0%	Planning During Construction		$76	$17	22%	$93	5.7%	$80	$18	$98	2017Q3	5.9%	$85	$19	$104
2.0%	Project Operations		$76	$17	22%	$93	5.7%	$80	$18	$98	2016Q3	1.9%	$82	$18	$100
31	CONSTRUCTION MANAGEMENT														
10.0%	Construction Management		$379	$83	22%	$462	5.7%	$400	$88	$489	2017Q3	5.9%	$424	$93	$517
2.0%	Project Operation:		$76	$17	22%	$93	5.7%	$80	$18	$98	2017Q3	5.9%	$85	$19	$104
2.5%	Project Management		$95	$21	22%	$116	5.7%	$100	$22	$122	2017Q3	5.9%	$106	$23	$130
18	CULTURAL RESOURCE PRESERVATION		$70			$70		$70		$70			$70		$70
	CONTRACT COST TOTALS:		$6,141	$1,549		**$7,690**		$6,382	$1,610	$7,992			$6,568	$1,653	**$8,220**

**** CONTRACT COST SUMMARY ****

PROJECT: Sacramento River Bank Protection Project - Economically Justified
LOCATION: Sacramento Valley - Various locations
This Estimate reflects the scope and schedule in report; Project X Major Rehabilitation Report June 2014

DISTRICT: SPD South Pacific Division
POC: CHIEF, COST ENGINEERING, xxx
PREPARED: 6/16/2014

Civil Works Work Breakdown Structure			**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
			Estimate Prepared:			6/2/2014	Program Year (Budget EC):			2016					
			Effective Price Level:			10/1/2013	Effective Price Level Date:			1 OCT 15					
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*		*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	CONTRACT 2														
16	BANK STABILIZATION	Butte Basin, Sacramento River 168.3 L	$1,290	$284	22%	$1,574	3.5%	$1,335	$294	$1,628	2018Q3	5.0%	$1,402	$308	$1,710
16	BANK STABILIZATION	Butte Basin, Sacramento River 172.0 L	$715	$157	22%	$872	3.5%	$740	$163	$902	2018Q3	5.0%	$777	$171	$948
16	BANK STABILIZATION	Natomas, Sacramento River 78.3 L	$1,304	$287	22%	$1,591	3.5%	$1,349	$297	$1,646	2018Q3	5.0%	$1,417	$312	$1,729

16	BANK STABILIZATION	Sacramento, Sacramento River 56.6 L	$386	$85	22%	$471	3.5%	$399	$88	$487	2018Q3	5.0%	$420	$92	$512
16	BANK STABILIZATION	Southport, Sacramento River 56.5 R	$1,487	$327	22%	$1,814	3.5%	$1,538	$338	$1,877	2018Q3	5.0%	$1,616	$356	$1,972
16	BANK STABILIZATION	Southport, Sacramento River 56.7 R	$3,824	$841	22%	$4,665	3.5%	$3,956	$870	$4,827	2018Q3	5.0%	$4,156	$914	$5,070
06	FISH & WILDLIFE FACILITIES	Natomas, Sacramento River 78.3 L	$205	$45	22%	$250	3.5%	$212	$47	$259	2018Q3	5.0%	$223	$49	$272
06	FISH & WILDLIFE FACILITIES	Butte Basin, Sacramento River 168.3 L	$117	$26	22%	$143	3.5%	$121	$27	$148	2018Q3	5.0%	$127	$28	$155
06	FISH & WILDLIFE FACILITIES	Butte Basin, Sacramento River 172.0 L	$25	$6	22%	$31	3.5%	$26	$6	$32	2018Q3	5.0%	$27	$6	$33
06	FISH & WILDLIFE FACILITIES	Sacramento, Sacramento River 56.6 L	$8	$2	22%	$10	3.5%	$8	$2	$10	2018Q3	5.0%	$9	$2	$11
06	FISH & WILDLIFE FACILITIES	Southport, Sacramento River 56.5 R	$37	$8	22%	$45	3.5%	$38	$8	$47	2018Q3	5.0%	$40	$9	$49
06	FISH & WILDLIFE FACILITIES	Southport, Sacramento River 56.7 R	$95	$21	22%	$116	3.5%	$98	$22	$120	2018Q3	5.0%	$103	$23	$126
								$0							
	CONSTRUCTION ESTIMATE TOTALS:		$9,493	$2,088	22%	**$11,581**		$9,821	$2,161	$11,982			$10,317	$2,270	$12,587
01	LANDS AND DAMAGES	Butte Basin, Sacramento River 168.3 L	$284	$133	47%	$417	3.5%	$294	$138	$431	2017Q3	3.0%	$303	$142	$444
01	LANDS AND DAMAGES	Butte Basin, Sacramento River 172.0 L	$568	$266	47%	$834	3.5%	$588	$275	$863	2017Q3	3.0%	$605	$283	$888
01	LANDS AND DAMAGES	Natomas, Sacramento River 78.3 L	$142	$66	47%	$208	3.5%	$147	$69	$216	2017Q3	3.0%	$151	$71	$222
01	LANDS AND DAMAGES	Sacramento, Sacramento River 56.6 L	$426	$199	47%	$625	3.5%	$441	$206	$647	2017Q3	3.0%	$454	$212	$666
01	LANDS AND DAMAGES	Southport, Sacramento River 56.5 R	$426	$199	47%	$625	3.5%	$441	$206	$647	2017Q3	3.0%	$454	$212	$666
01	LANDS AND DAMAGES	Southport, Sacramento River 56.7 R	$284	$133	47%	$417	3.5%	$294	$138	$431	2017Q3	3.0%	$303	$142	$444
30	PLANNING, ENGINEERING & DESIGN														
2.5%	Project Management		$237	$52	22%	$289	5.7%	$250	$55	$306	2017Q3	5.9%	$265	$58	$324
2.0%	Planning & Environmental Compliance		$190	$42	22%	$232	5.7%	$201	$44	$245	2017Q3	5.9%	$213	$47	$259
8.5%	Engineering & Design		$807	$178	22%	$985	5.7%	$853	$188	$1,040	2017Q3	5.9%	$903	$199	$1,102
0.5%	Reviews, ATRs, IEPRs, VE		$47	$10	22%	$57	5.7%	$50	$11	$61	2017Q3	5.9%	$53	$12	$64
0.5%	schedule, risks)		$47	$10	22%	$57	5.7%	$50	$11	$61	2017Q3	5.9%	$53	$12	$64
2.0%	Contracting & Reprographics		$190	$42	22%	$232	5.7%	$201	$44	$245	2017Q3	5.9%	$213	$47	$259
3.0%	Engineering During Construction		$285	$63	22%	$348	5.7%	$301	$66	$367	2018Q3	10.0%	$331	$73	$404
2.0%	Planning During Construction		$190	$42	22%	$232	5.7%	$201	$44	$245	2018Q3	10.0%	$221	$49	$270
2.0%	Project Operations		$190	$42	22%	$232	5.7%	$201	$44	$245	2017Q3	5.9%	$213	$47	$259
31	CONSTRUCTION MANAGEMENT														
10.0%	Construction Management		$949	$209	22%	$1,158	5.7%	$1,003	$221	$1,223	2018Q3	10.0%	$1,103	$243	$1,346
2.0%	Project Operation:		$190	$42	22%	$232	5.7%	$201	$44	$245	2018Q3	10.0%	$221	$49	$270
2.5%	Project Management		$237	$52	22%	$289	5.7%	$250	$55	$306	2018Q3	10.0%	$276	$61	$336
18	CULTURAL RESOURCE PRESERVATION		$173			$173		$173		$173			$173		$173
	CONTRACT COST TOTALS:		$15,355	$3,868		**$19,224**		$15,959	$4,019	$19,978			$16,823	$4,226	**$21,049**

**** CONTRACT COST SUMMARY ****

PROJECT: Sacramento River Bank Protection Project - Economically Justified
LOCATION: Sacramento Valley - Various locations
This Estimate reflects the scope and schedule in report; Project X Major Rehabilitation Report June 2014

DISTRICT: SPD South Pacific Division
POC: CHIEF, COST ENGINEERING, xxx
PREPARED: 6/16/2014

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared:			6/2/2014	Program Year (Budget EC):			2016					
			Effective Price Level:			10/1/2013	Effective Price Level Date:			1 OCT 15					
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*		*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	CONTRACT 3														
02	RELOCATIONS	Sutter Island, Steamboat Slough 24.7 R	$203	$45	22%	$248	3.5%	$210	$46	$256	2019Q3	7.1%	$225	$50	$275
02	RELOCATIONS	Sutter Island, Steamboat Slough 25.8 R	$82	$18	22%	$100	3.5%	$85	$19	$103	2019Q3	7.1%	$91	$20	$111
02	RELOCATIONS	Sutter Island, Steamboat Slough 23.9 R	$87	$19	22%	$106	3.5%	$90	$20	$110	2019Q3	7.1%	$96	$21	$118
02	RELOCATIONS	Yolo, Cache Creek 3.9 L	$307	$68	22%	$375	3.5%	$318	$70	$387	2019Q3	7.1%	$340	$75	$415
06	FISH & WILDLIFE FACILITIES	West Sacramento, Sacramento River 62.9 R	$13	$3	22%	$16	3.5%	$13	$3	$16	2019Q3	7.1%	$14	$3	$18

WBS	Feature	Sub-Feature	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	ESC (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
06	FISH & WILDLIFE FACILITIES	West Sacramento, Sacramento River 63.0 R	$6	$1	22%	$7	3.5%	$6	$1	$8	2019Q3	7.1%	$7	$1	$8
06	FISH & WILDLIFE FACILITIES	Sutter Island, Sutter Slough 26.5 L	$22	$5	22%	$27	3.5%	$23	$5	$28	2019Q3	7.1%	$24	$5	$30
06	FISH & WILDLIFE FACILITIES	Sutter Island, Steamboat Slough 23.9 R	$229	$50	22%	$279	3.5%	$237	$52	$289	2019Q3	7.1%	$254	$56	$310
06	FISH & WILDLIFE FACILITIES	Sutter Island, Steamboat Slough 25.8 R	$229	$50	22%	$279	3.5%	$237	$52	$289	2019Q3	7.1%	$254	$56	$310
06	FISH & WILDLIFE FACILITIES	Sutter Island, Steamboat Slough 24.7 R	$377	$83	22%	$460	3.5%	$390	$86	$476	2019Q3	7.1%	$418	$92	$510
11	LEVEES & FLOODWALLS	Sutter Island, Steamboat Slough 25.8 R	$494	$109	22%	$603	3.5%	$511	$112	$624	2019Q3	7.1%	$548	$120	$668
11	LEVEES & FLOODWALLS	Sutter Island, Steamboat Slough 24.7 R	$1,025	$226	22%	$1,251	3.5%	$1,060	$233	$1,294	2019Q3	7.1%	$1,136	$250	$1,386
11	LEVEES & FLOODWALLS	Sutter Island, Steamboat Slough 23.9 R	$558	$123	22%	$681	3.5%	$577	$127	$704	2019Q3	7.1%	$619	$136	$755
11	LEVEES & FLOODWALLS	Yolo, Cache Creek 3.9 L	$2,105	$463	22%	$2,568	3.5%	$2,178	$479	$2,657	2019Q3	7.1%	$2,333	$513	$2,847
16	BANK STABILIZATION	Sutter Island, Sutter Slough 26.5 L	$2,590	$570	22%	$3,160	3.5%	$2,680	$589	$3,269	2019Q3	7.2%	$2,871	$632	$3,503
16	BANK STABILIZATION	West Sacramento, Sacramento River 63.0 R	$323	$71	22%	$394	3.5%	$334	$74	$408	2019Q3	7.2%	$358	$79	$437
16	BANK STABILIZATION	West Sacramento, Sacramento River 62.9 R	$448	$99	22%	$547	3.5%	$463	$102	$565	2019Q3	7.2%	$497	$109	$606
								$0							
	CONSTRUCTION ESTIMATE TOTALS:		$9,098	$2,002	22%	**$11,100**		$9,412	$2,071	$11,483			$10,085	$2,219	$12,304
01	LANDS AND DAMAGES	Sutter Island, Steamboat Slough 24.7 R	$390	$183	47%	$573	3.5%	$403	$189	$592	2018Q3	5.0%	$424	$198	$622
01	LANDS AND DAMAGES	Sutter Island, Steamboat Slough 25.8 R	$195	$91	47%	$286	3.5%	$202	$94	$296	2018Q3	5.0%	$212	$99	$311
01	LANDS AND DAMAGES	Sutter Island, Steamboat Slough 23.9 R	$195	$91	47%	$286	3.5%	$202	$94	$296	2018Q3	5.0%	$212	$99	$311
01	LANDS AND DAMAGES	Sutter Island, Sutter Slough 26.5 L	$142	$66	47%	$208	3.5%	$147	$69	$216	2018Q3	5.0%	$154	$72	$227
01	LANDS AND DAMAGES	West Sacramento, Sacramento River 62.9 R	$284	$133	47%	$417	3.5%	$294	$138	$431	2018Q3	5.0%	$309	$144	$453
01	LANDS AND DAMAGES	West Sacramento, Sacramento River 63.0 R	$284	$133	47%	$417	3.5%	$294	$138	$431	2018Q3	5.0%	$309	$144	$453
01	LANDS AND DAMAGES	Yolo, Cache Creek 3.9 L	$426	$199	47%	$625	3.5%	$441	$206	$647	2018Q3	5.0%	$463	$217	$680
30	PLANNING, ENGINEERING & DESIGN														
2.5%	Project Management		$227	$50	22%	$277	5.7%	$240	$53	$293	2018Q3	10.0%	$264	$58	$322
2.0%	Planning & Environmental Compliance		$182	$40	22%	$222	5.7%	$192	$42	$235	2018Q3	10.0%	$212	$47	$258
8.5%	Engineering & Design		$773	$170	22%	$943	5.7%	$817	$180	$997	2018Q3	10.0%	$899	$198	$1,096
0.5%	Reviews, ATRs, IEPRs, VE		$45	$10	22%	$55	5.7%	$48	$10	$58	2018Q3	10.0%	$52	$12	$64
0.5%	schedule, risks)		$45	$10	22%	$55	5.7%	$48	$10	$58	2018Q3	10.0%	$52	$12	$64
2.0%	Contracting & Reprographics		$182	$40	22%	$222	5.7%	$192	$42	$235	2018Q3	10.0%	$212	$47	$258
3.0%	Engineering During Construction		$273	$60	22%	$333	5.7%	$288	$63	$352	2019Q3	14.4%	$330	$73	$403
2.0%	Planning During Construction		$182	$40	22%	$222	5.7%	$192	$42	$235	2019Q3	14.4%	$220	$48	$268
2.0%	Project Operations		$182	$40	22%	$222	5.7%	$192	$42	$235	2018Q3	10.0%	$212	$47	$258
31	CONSTRUCTION MANAGEMENT														
10.0%	Construction Management		$910	$200	22%	$1,110	5.7%	$962	$212	$1,173	2019Q3	14.4%	$1,100	$242	$1,342
2.0%	Project Operation:		$182	$40	22%	$222	5.7%	$192	$42	$235	2019Q3	14.4%	$220	$48	$268
2.5%	Project Management		$227	$50	22%	$277	5.7%	$240	$53	$293	2019Q3	14.4%	$274	$60	$335
18	CULTURAL RESOURCE PRESERVATION		$168			$168		$168		$168			$168		$168
	CONTRACT COST TOTALS:		$14,592	$3,648		**$18,240**		$15,166	$3,791	$18,957			$16,382	$4,083	**$20,465**

**** CONTRACT COST SUMMARY ****

PROJECT: Sacramento River Bank Protection Project - Economically Justified
LOCATION: Sacramento Valley - Various locations
This Estimate reflects the scope and schedule in report; Project X Major Rehabilitation Report June 2014

DISTRICT: SPD South Pacific Division
POC: CHIEF, COST ENGINEERING, xxx
PREPARED: 6/16/2014

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 6/2/2014 Effective Price Level: 10/1/2013				Program Year (Budget EC): 2016 Effective Price Level Date: 1 OCT 15				FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*		*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	CONTRACT 4														
16	BANK STABILIZATION	Yolo, Knights Landing Ridge Cut 0.2 R	$178	$39	22%	$217	3.5%	$184	$41	$225	2020Q3	9.3%	$201	$44	$246
16	BANK STABILIZATION	Rio Oso, Bear River 0.8 L	$539	$119	22%	$658	3.5%	$558	$123	$680	2020Q3	9.3%	$609	$134	$744
16	BANK STABILIZATION	Rio Oso, Feather River 0.6 L	$871	$192	22%	$1,063	3.5%	$901	$198	$1,099	2020Q3	9.3%	$985	$217	$1,202

16	BANK STABILIZATION	Rio Oso, Feather River 5.0 L	$2,072	$456	22%	$2,528	3.5%	$2,144	$472	$2,615	2020Q3	9.3%	$2,343	$515	$2,858
06	FISH & WILDLIFE FACILITIES	Rio Oso, Feather River 0.6 L	$109	$24	22%	$133	3.5%	$113	$25	$138	2020Q3	9.3%	$123	$27	$150
06	FISH & WILDLIFE FACILITIES	Rio Oso, Feather River 5.0 L	$311	$68	22%	$379	3.5%	$322 $0	$71	$393	2020Q3	9.3%	$352	$77	$429
	CONSTRUCTION ESTIMATE TOTALS:		$4,080	$898	22%	**$4,978**		$4,221	$929	$5,150			$4,613	$1,015	$5,628
01	LANDS AND DAMAGES	Yolo, Knights Landing Ridge Cut 0.2 R	$396	$185	47%	$581	3.5%	$410	$192	$601	2019Q3	7.2%	$439	$205	$644
01	LANDS AND DAMAGES	Rio Oso, Bear River 0.8 L	$142	$66	47%	$208	3.5%	$147	$69	$216	2019Q3	7.2%	$157	$74	$231
01	LANDS AND DAMAGES	Rio Oso, Feather River 0.6 L	$284	$133	47%	$417	3.5%	$294	$138	$431	2019Q3	7.2%	$315	$147	$462
01	LANDS AND DAMAGES	Rio Oso, Feather River 5.0 L	$284	$133	47%	$417	3.5%	$294	$138	$431	2019Q3	7.2%	$315	$147	$462
30	PLANNING, ENGINEERING & DESIGN														
2.5%	Project Management		$102	$22	22%	$124	5.7%	$108	$24	$131	2019Q3	14.4%	$123	$27	$150
2.0%	Planning & Environmental Compliance		$82	$18	22%	$100	5.7%	$87	$19	$106	2019Q3	14.4%	$99	$22	$121
8.5%	Engineering & Design		$347	$76	22%	$423	5.7%	$367	$81	$447	2019Q3	14.4%	$419	$92	$512
0.5%	Reviews, ATRs, IEPRs, VE		$20	$4	22%	$24	5.7%	$21	$5	$26	2019Q3	14.4%	$24	$5	$29
0.5%	schedule, risks)		$20	$4	22%	$24	5.7%	$21	$5	$26	2019Q3	14.4%	$24	$5	$29
2.0%	Contracting & Reprographics		$82	$18	22%	$100	5.7%	$87	$19	$106	2019Q3	14.4%	$99	$22	$121
3.0%	Engineering During Construction		$122	$27	22%	$149	5.7%	$129	$28	$157	2020Q3	18.9%	$153	$34	$187
2.0%	Planning During Construction		$82	$18	22%	$100	5.7%	$87	$19	$106	2020Q3	18.9%	$103	$23	$126
2.0%	Project Operations		$82	$18	22%	$100	5.7%	$87	$19	$106	2019Q3	14.4%	$99	$22	$121
31	CONSTRUCTION MANAGEMENT														
10.0%	Construction Management		$408	$90	22%	$498	5.7%	$431	$95	$526	2020Q3	18.9%	$513	$113	$625
2.0%	Project Operation:		$82	$18	22%	$100	5.7%	$87	$19	$106	2020Q3	18.9%	$103	$23	$126
2.5%	Project Management		$102	$22	22%	$124	5.7%	$108	$24	$131	2020Q3	18.9%	$128	$28	$156
18	CULTURAL RESOURCE PRESERVATION		$78			$78		$78		$78			$78		$78
	CONTRACT COST TOTALS:		$6,795	$1,752		**$8,547**		$7,061	$1,820	$8,881			$7,806	$2,004	**$9,810**

ENCLOSURE 5

Agricultural Damage Analysis

Agricultural Flood Damages

The Planning Guidance Notebook of the USACE (ER 1105-2-100) and the IWR Report 87-R-10 provide guidance and rules on the treatment of agricultural crops. These documents serve as the basis for the agricultural analyses. Further, damages expressed as annual values are calculated utilizing the FY13 discount rate of 3.75 percent with an analysis period of 50 years. All benefits and costs are expressed at an October 2012 price level. The base operational year is 2014.

ER 1105-2-100, Appendix E, beginning on page E-113 includes specific guidance for studies where the primary damages occur to agricultural crops. These damages are directly related, and evaluated with special consideration for the expected time of seasonal flooding as well as the variability associated with crop prices and yields. The identified hydrologic/hydraulic variables, discharge associated with exceedence frequency and conveyance roughness and cross-section geometry, also apply to agricultural studies. The crop damage is directly related to the duration of flooding, and is evaluated accordingly. Procedurally, the damage assessment is coordinated with the residential and non-residential structural analysis conducted in typical USACE fashion employing the HEC-FDA damage assessment model.

Farm Budget and Crop Data

The preponderance of the study area lies within or adjacent to two Counties with the Sacramento River Valley. Accordingly, evaluation of each analytical area is analyzed based on the yields and seasonal variations related to the County which is closest in proximity. Agricultural crop acreage was developed by Sacramento District COE on a GIS basis with the assistance of the Agricultural Commissioner's office in Sacramento and Sutter Counties. GIS mapping of agriculture allows for the overlaying of Flo2D flood plain mapping thereby identifying flooded acreage by crop type. Various crop budgets were obtained from the University of California at Davis' Agricultural & Resource Economics web site. Historical crop yields and values for various flood plain crops were obtained from the U.S. Department of Agriculture, National Agricultural Statistics Service web site of the Sacramento and Sutter County's Agricultural Commissioner's Annual Crop Report. Agricultural land restoration costs are based on previous USACE studies and farm budget reports. Monthly flood probabilities were derived based on the percentage of historical annual peak discharges occurring in each month as documented by the Water Management Section, Sacramento District COE.

Agricultural Economic Damages Related to Flooding in Sutter Study Area, California

The analysis below outlines the general concepts and procedures used in the computation of the agricultural damages incurred by assumed flood events within the study area.

Procedures used in the Estimation of Agricultural Damages

The discussion below indicates considerations used in the computation of agricultural damages within the Sacramento River Basin Study Area.

The current land use for the Study Area was secured from the County Assessor data identified as the agricultural land area for each flood event.

The land/crop uses were categorized into six general categories for analytical and reporting purposes. The five general categories of land/crop use are:

1. Truck and Specialty Crops – including processing tomatoes
2. Field Crops – including row crops like corn and wheat
3. Orchard – including crops like Walnuts and Almonds
4. Alfalfa and Irrigated Pasture
5. Rice
6. Other – including lands irrigated and native pasture and lands that are idle, semi-agricultural, and native vegetation

Agricultural damages due to flooding for each acre are computed by adding four elements:

1) The cumulative direct production or annual variable costs incurred prior to flooding
2) The net value of the crop affected by the flood event
3) Depreciated value of perennial crops lost as a direct result of flooding
4) The land clean-up and rehabilitation resulting from flooding

Direct Production Costs

Cultural costs are incurred periodically throughout the crop year. Examples of these direct production costs include: seedbed preparation, chemical and fertilizer application, hired labor, seed, planting, and weed and pest control. These individual crop costs for the five crops are computed on a monthly basis to determine the amount of expended cultural costs at the time of the flood event. An example of the monthly production costs is included in Table 2 for the production of processing tomatoes in the study area.

Net Value of Crop

The second component represents the net income of the crop plus return to fixed items of production such as land, labor and management, real estate taxes, and fixed costs associated with pre-harvest and harvest activities. The net value of the crop is the amount of revenue that the producer may not get if a significant flood event were to occur of his property.

Seasonality

Computationally, the season of the year that the flood occurs greatly impacts amount of flood damage to the agricultural crop. If flooding occurs early within the year, the producer may be able to re-prepare the seedbed, plant and realize a return on his efforts. Conversely, a flood of substantial proportion occurring at harvest time will most certainly result in complete loss for the entire year.

The probability of a storm occurrence, and accompanying flood damage, in any particular month was provided by the District Hydrologist for the Study area vicinity and displays the likelihood of a storm occurring for each month throughout the year.

Farm budgets were obtained from the University of California at Davis. The monthly probability of flood occurrence was derived from peak annual flow data secured from the Water Management Section, USACE, Sacramento District. Due to year-to-year variability flood occurrences may be as much as 4 weeks early or later than the flood occurrence midpoint. These flood occurrence probabilities for the Sacramento River Basin Study area (Sacramento and Sutter Counties) are displayed below showing the flood event probabilities with uncertainty associated with each month:

Table 1 - Monthly Flood Occurrence Probabilities

Month	Sacramento County Probability		
	Scenario Midpoint	Scenario Beginning	Scenario Ending
January	0.210	0.170	0.310
February	0.310	0.210	0.170
March	0.170	0.310	0.080
April	0.080	0.170	0.010
May	0.010	0.090	0.000
June	0.000	0.010	0.000
July	0.000	0.000	0.000
August	0.000	0.000	0.000
September	0.000	0.000	0.010
October	0.010	0.000	0.040
November	0.040	0.010	0.170
December	0.170	0.040	0.210

Month	Sutter County Probability		
	Scenario Midpoint	Scenario Beginning	Scenario Ending
January	0.220	0.160	0.310
February	0.310	0.220	0.150
March	0.150	0.310	0.100
April	0.100	0.150	0.010
May	0.010	0.100	0.000
June	0.000	0.010	0.000
July	0.000	0.000	0.000
August	0.000	0.000	0.000
September	0.000	0.000	0.010
October	0.010	0.000	0.040
November	0.040	0.010	0.160
December	0.160	0.040	0.220

Multiplying the direct production costs and the value of crop at risk for each month times the monthly probability provides the probable damages expected if a flood event occurred in any particular month. Uncertainty parameters were used in the overall computation of both direct production losses and the net incomes for each crop impacted.

Value of Perennial Crops

Damage caused by long-term duration flooding may result in permanent loss of perennial crops. The damage to perennials susceptible to flooding is computed based upon the assumption that the crop stands are at various ages, ranging from year 1 throughout their economic useful life. Accordingly, damage caused by long-term duration flooding is computed based upon a stand that is at the mid-point of its economic useful life.

Clean-up and Rehabilitation

Erosion and deposition of debris and sediment may be caused by floods of any duration or time of year. Additionally, drainage and irrigation ditches may become clogged with silt and debris. Interviews with cooperative extension agents and local farmers have been conducted over the past several years. Clean-up and rehabilitation of farm acreage is a genuine flood loss and is accordingly accounted for in the computation of agricultural flood damages.

Restoration of Field Cropland after Flooding

The requirement to restore agricultural land after having been inundated by flood will require the removal of trash and debris that may have accumulated, dealing with sediment deposition, and reworking of fields to incorporate the sediment and re-level the irrigated cropland. The restoration costs are based on estimates of cultural procedures from the University of California, Davis and range, for this type of flooding, from a cost of $0 to $92 for open cropland. This level of restoration requirement is consistent with the post-flood demands identified in other USACE studies. The estimated cost for agricultural land restoration requiring the largest amount of clean-up and restoration effort on a per acre basis is:

Table 2 – Per Acre Field Cropland Restoration Costs

Operation	$ Cost/per Acre
Debris/Trash Removal	16.00
Chisel Plow (2X)	22.00
Disc and Roll (2X)	16.00
Triplane (2X)	22.00
Repair/Replace Irrigation System	16.00
Total (50% of acres)	92.00

The average cleanup and restoration costs over the entire floodplain are estimated occur on approximately one-half of the affected acres or $46 per acre. It is noted that the restoration costs include only those costs that re-establish the land to a condition prior to the incurrence of any of the expected annual production costs. Accordingly, restoration costs do not provide for fertilizing, applying herbicide, or any pre-planting activities that are expected to occur during the normal growing season.

Pollutants

In an article in the Los Angeles Times dated March 22, 2010 writer John Flesher discussed the possible environmental hazards associated with flooding in the Fargo North Dakota area. These factors are similar to what could be expected in the Sacramento River Bank Study Area and are provided for informational purposes and, to the extent possible, are included in this economic analysis.

> *Floodwaters can be noxious brews of pesticides, sewage, garbage and animal carcasses that foul drinking water, spread disease and damage fish habitat. Although the Red River didn't do nearly as much damage this year as during record-breaking floods in 2009, authorities say danger could persist.*
>
> *"Fuels, chemicals, all kinds of things find their way into the water system and it's a huge environmental risk," said Keith Berndt, engineer for Cass County, which includes Fargo and West Fargo.*
>
> *"We don't want people to use used sand for old sand bags in their kids' sand boxes or anywhere else they could come in direct contact with it," said Myron Bergland, environmental health manager for Fargo-Cass Public Health.*

Last year's disaster (2009) swept pollutants into the Red and its tributaries, although the sheer volume of water and accelerated flow rate weakened the effect, said David Glatt, environmental chief for the North Dakota Department of Health. Even as officials were ready to declare victory in this year's flood fight, Glatt emphasized the importance of safeguarding drinking water supplies, particularly in rural areas where private wells may have been submerged.

No large-scale water-quality testing was conducted in 2009, but officials monitored hospital emergency rooms and found no upswing in visits that would have indicated an outbreak of flood-related sickness, Glatt said. Officials credited experience and public education with preventing serious environmental health problems.

"We've had a little familiarity with floods in recent history," Glatt said. "People have had an opportunity to prepare and minimize the harm."

Cities in the region have reduced their exposure to contaminated water over the years by elevating wellheads or surrounding them with dikes to keep floodwaters out. But numerous wastewater treatment systems were overwhelmed during last year's flooding, forcing officials to dump raw sewage into the rivers. A few have requested permission to do likewise this year if necessary.

Private well users are particularly vulnerable. State and local agencies have provided information about protecting residential wells and stand ready to help disinfect contaminated ones. Fargo-Cass Public Health last week warned owners of submerged wells not to use the water for drinking or cooking until it can be tested. Agencies also urged people to secure household and farm chemicals, fuel tanks and other potential sources of pollution.

Dead livestock is a particular threat in Great Plains ranch country. Some 90,000 head of cattle were lost during last year's calamity. They're a potential source of pathogens that can pollute wells and surface waters.

"Even a typically normal, healthy cow has E. coli bacteria in its gut," Bergland said. "You need to properly dispose of the bodies before they drift away in the water."

State agencies, including the North Dakota National Guard, helped retrieve bloated carcasses and advised ranchers how to deal with them. It's not as simple as it sounds. If buried, the bodies must be placed above the water table under at least 4 feet of loamy, clay soils. If burned, only organic fuels such as wood can be used and a state permit is required.

Once immediate flood dangers have passed, ecological aftereffects can persist for months or years.

Phosphorus fertilizers that wash into rivers and lakes can stimulate growth of algae blooms that reduce oxygen levels and kill fish. Heavy soil erosion along riverbanks degrades fish habitat and spawning areas, particularly in streams that feed larger rivers such as the Red.

"Think of trying to breathe in a dust storm," said Henry Van Offelen, a scientist with the Minnesota Center for Environmental Advocacy. "That's what a big sediment plume in water is for fish."

But the environmental setbacks are not always a total loss. Some of the leftover bag sand can be used in landfills to prevent liquid pollution from seeping into groundwater.

Special Consideration for Specialty, Truck Crops, and Selected Field Crops

Vegetable crops raised for direct human consumption are vulnerable to passing on the E.Coli bacteria to humans through contamination from animals. In 2006 an E. coli outbreak traced to bagged spinach was blamed for the deaths of three people and for sickening hundreds more across the U.S. Authorities ultimately identified a central California cattle ranch next to a spinach field as being the source of the bacteria. In 2007 salad mix packaged by a major food processor tested positive for E.coli and triggered a recall in at least nine states. The ultimate cost to the processor and the producers are unknown but is determined to be of significant proportions and is deemed to be life threatening.

Between 1999 and 2006, there were 12 outbreaks of E. Coli traced to California leafy greens resulting in 539 reported illnesses. Of those 12 outbreaks, 10 were on fresh-cut leafy greens and those 10 outbreaks involved 531 of the illnesses. In addition to E. Coli, a recent announcement from the Centers for Disease Control and Prevention on June 11 of 2008 confirms that a salmonella outbreak has struck at least 167 people in 17 states. The Food and Drug Administration estimates that an average of 2 to 4 million cases of salmonellosis occur annually in the U.S. This particular outbreak is linked with raw tomatoes infected by microscopic bacteria that live in the intestinal tracks of people and animals. The infection is spread by the ingestion of raw or undercooked food and water that is contaminated with feces carrying the bacteria. Contaminated goods usually stem from animal origin but are not limited to and often include vegetation and water. Already, restaurants and supermarkets have either stopped selling tomatoes altogether or only carry tomatoes deemed safe by the FDA.

Even slight flooding of fields has the associated probability of carrying animal waste in the floodwater, and accordingly, may carry the E.coli and salmonella bacteria. In an article titled *Transmission of Escherichia coli 0157:H7 from Contaminated Manure and Irrigation Water to Lettuce Plant tissue and Its Subsequent Internalization,*[1] the authors stated: " *Application of E.coli 0517:H7-contaiminated manure to the production field or irrigation with E.coli 0157:H7-contaminated water may result in contamination of the crop in the field. Studies have indicated the E.coli can survive for extended periods in manure and water. We have demonstrated that lettuce grown in soil containing contaminated manure, or irrigated with contaminated water, results in contamination of the edible portion of the lettuce plant. Moreover, the results suggest that edible portions of a plant can become contaminated without direct exposure to a pathogen, but rather through transport of the pathogen into the plant by the root system.*"

In a November 4, 2005, FDA "Letter to California Firms that Grow, Pack, Process, or Ship Fresh and Fresh-cut Lettuce[12]," the Agency stated as follows:

FDA considers ready to eat crops (such as lettuce) that have been in contact with flood waters to be adulterated due to potential exposure to sewage, animal waste, heavy metals, pathogenic microorganisms, or other contaminants. FDA is not aware of any method of reconditioning these crops that will provide a reasonable assurance of safety for human food use or otherwise bring them into compliance with the law. Therefore, FDA recommends that such crops be excluded from the human food supply and disposed of in a manner that ensures they do not contaminate unaffected crops during harvesting, storage or distribution. Adulterated food may be subject to seizure under the Federal Food, Drug, and Cosmetic Act, and those responsible for its introduction or delivery for introduction into interstate commerce may be enjoined from continuing to do so or prosecuted for having done so . . . [F]ood produced under unsanitary conditions whereby it may be rendered injurious to health is adulterated under section 402(a)(4) of the Act (21 U.S.C. 342(a)(4)).
Situations related to flooding can be separated into three groups: (1) a product that has come into contact with flood water, (2) a product that is in proximity to a flooded area but has not come in contact with flood water, and (3) a production field which was partially or completely flooded in the past before a crop was planted. The recommendations for each situation are provided below.
For a product that has come into contact with flood water, FDA recommends:

- Excluding such crops from the human food supply and disposing of them in a manner that ensures they do not contaminate unaffected crops during harvesting, storage or distribution.

For a product that is in proximity to a flooded area but has not come in contact with flood water, FDA recommends:

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[1] Subject article written by Ethan B. Solomon, Sima Yaron, and Karl R. Matthews, Department of Food Science, Rutgers University, New Brunswick, New Jersey, appeared in "Applied and Environmental Microbiology," January 2002, p. 397-400, Vol 68, No. 108901.

- Preventing cross contamination between flooded and non-flooded areas (e.g., cleaning equipment, eliminating contact of any farming or harvesting equipment or personnel with the flooded area during production and harvest of crop in non-flooded areas).

For formerly flooded production ground, FDA recommends:

- Assessing field history and crop selection.
- Determining the time interval between the flooding event, crop planting, and crop harvest.
- Determining the source of flood waters (e.g., drainage canal, river, or irrigation canal) and whether there are significant upstream potential contributors of human pathogens.
- Allowing soils to dry sufficiently and be reworked prior to subsequently planting crops on formerly flooded production ground.
- Sampling previously flooded soil for the presence of microorganisms of significant public health concern or appropriate indicator microorganisms. Note: Microbial soil sampling can provide valuable information regarding relative risks, but sampling by itself does not guarantee that all raw agricultural commodities grown within the formerly flooded production area are free of the presence of human pathogens.

The National Organic Producer regulation provides guidelines on the use of manure that is applied to the croplands. There are several conditions of manure being either composted, worked into the soil, or when it comes into contact with the edible portion of the crop.

> *The producer must manage plant and animal materials to maintain or improve soil organic matter content in a manner that does not contribute to contamination of crops, soil, or water by plant nutrients, pathogenic organisms, heavy metals, or residues of prohibited substances. Animal and plant materials include:*
>
> *(1) Raw animal manure, which must be composted unless it is:*
>
> *(i) Applied to land used for a crop not intended for human consumption;*
>
> *(ii) Incorporated into the soil not less than 120 days prior to the harvest of a product whose edible portion has direct contact with the soil surface or soil particles; or*
>
> *(iii) Incorporated into the soil not less than 90 days prior to the harvest of a product whose edible portion does not have direct contact with the*

soil surface or soil particles;

For purposes of this analysis, any flooding of truck crop acreage will result in the assumption that the vegetables are not fit for human consumption and valued as a total loss. It is deemed to be inappropriate to assume any salvage of vegetable matter for human consumption considering the risks associated with these deadly bacteria.

Planting of lands that have previously been flooded are not expected to be adversely affected since the organic materials are assumed to be incorporated into the soil well in advance of the time constraints currently provided by national guidelines.

Agricultural Acreage and Yields - No Failure due to Levee Erosion

The alternative discussed in the following several pages is based on an assumed scenario where no erosion damage is present. Two other alternatives are discussed and compared near the end of this report. This alternative is discussed at length to provide the reader with an understanding of the methodology that has gone in to the alternative evaluations.

The study area contains approximately 530,000 acres of agricultural lands that are subject to flooding. About 41,000 acres of the affected floodplain is devoted to high value orchard and grape production with about 60,000 acres planted annually to crops including truck crops such as processing tomatoes. Rice comprises about 186,000 acres and the remaining acreage is primarily devoted to field crops, pasture, and alfalfa hay. These agricultural products have been consolidated into 6 different farm budget analyses. In addition to the damages revealed through farm budget analysis, damages for cropland and associated restoration have been included in the analysis.

Table 3. Acreage Inundated by Flood Event- Study Area

	------------------ Flood Frequency ------------------------						
	5	10	20	50	100	200	500
FRUITS AND NUTS	0	7,827	0	22,842	27,557	33,324	35,992
FIELD CROPS	0	17,796	0	115,208	136,091	160,490	170,622
PASTURE & ALFALFA	0	4,894	0	21,854	24,829	31,005	33,406
RICE	0	66,469	0	122,139	135,307	171,958	185,532
TRUCK CROPS	0	2,331	0	44,570	52,437	55,360	59,574
VINE CROPS	0	0	0	3,895	5,014	5,038	5,370
OTHER	0	8,800	0	19,772	23,228	34,859	40,232
TOTAL	0	108,117	0	350,280	404,463	492,034	530,728

Procedurally the damages are calculated for each flood event within each area of analysis. Tables 4 and 5 below display the areas of analysis and the acreage that were evaluated for each flood event.

Table 4. Acreage Inundated by Flood Event-
Sacramento County Associated Impact Areas

	------------------ Flood Frequency --------------------				
	10	50	100	200	500
Tyler Island	0	8,680	8,685	8,690	8,695
Clarksburg	0	12,028	20,465	20,476	22,375
Hastings Tract	0	3,411	3,414	3,414	3,419
Ryer Island	0	10,974	11,278	11,278	11,278
Yolo	0	5,432	5,433	5,434	5,916
Grand Island	0	15,681	15,681	15,681	15,687
Sutter Island	0	2,241	2,241	2,241	2,241
Woodland	0	3,423	5,075	5,760	10,777
Natomas	0	0	0	39,417	41,014
Elkhorn	0	11,881	11,923	11,923	11,923
West Sacramento	0	0	0	456	564
Sacramento	0	0	0	1,947	2,425
Southport	0	0	0	2,851	3,267
Merrit Island	0	4,577	4,595	4,639	4,639
Brannan Andrus	0	13,346	13,348	13,348	13,354

Table 5. Acreage Inundated by Flood Event-
Sutter County Associated Impact Areas

------------------ Flood Frequency --------------------

	10	50	100	200	500
Butte Basin	108,117	116,667	118,013	121,562	126,904
North Sutter	0	0	31,421	31,445	31,507
Linda	0	0	6,757	7,527	9,020
Grimes	0	84,194	88,128	98,696	111,613
South Sutter	0	54,397	54,658	55,263	63,742
Rio Oso	0	0	0	26,638	27,020
Knights Landing	0	3,348	3,348	3,348	3,348

Typical Farm Budget Example

A typical farm budget analysis employed for this analysis is shown in Table 6 below as is provided to illustrate the cultural practices and cost considerations that are in the typical farm budget analysis process.

Table 6 – Winter Wheat Farm Budget Analysis

	U.C. COOPERATIVE EXTENSION												
	MONTHLY COSTS PER ACRE TO PRODUCE WINTER WHEAT												
	SACRAMENTO – 2009												
	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	TOTAL**
Cultural:													
Land Prep – Disc 2X	13		12								5		30
Preplant - Incorporate Fertilizer			55										55
Land Prep – Border Disk, List Beds			12										12
Plant Wheat,& Apply P2O5 -25% acres				35									35
Weed Control							10						10
Fertilize Top Dress N -50%acres							45						45
Disease Control – Strip Rust -25% acres									5				5
Open /Close Ditch									4				4
Irrigate									30				30
Pickup Truck /ATV – (wheat business)	1	1	1	1	1	1	1	1	1				9
TOTAL CULTURAL COSTS	**14**	**1**	**80**	**36**	**1**	**1**	**56**	**1**	**40**		**5**		**235**
Harvest:											22		22
Bank Out Grain:											6		6
Haul Grain to Storage											80		80
TOTAL HARVEST COSTS											**108**		**108**
Interest on Operating Capital @ 5.75%				1	1	1	1	1	1	1	1		8
TOTAL OPERATING COSTS/ACRE:	**14**	**1**	**80**	**37**	**2**	**2**	**57**	**2**	**41**	**1**	**114**		**351**
OVERHEAD:													
Office Expense	1	1	1	1	2	1	2	1	2	1	2	1	16
Supervisor’s Salary	1	2	1	2	1	2	1	2	1	2	1	1	17
Land Rent	6	7	7	7	7	6	7	7	7	7	7	7	82
Field Sanitation						1						1	2
Property Taxes/Insurance						4						3	7
Investment Repairs						1	1	1	1				4
TOTAL OVERHEAD COSTS	8	10	9	10	10	15	11	11	11	10	10	13	128
TOTAL COSTS/ACRE	**22**	**11**	**89**	**47**	**12**	**17**	**68**	**13**	**52**	**11**	**124**	**13**	**479**

** Totals do not necessarily add due to rounding of monthly data.

Through farm budget analysis the per-acre damage has been determined at the following values for the analyzed crops of the study area.

A Palisades software program @Risk was used for evaluation of gross receipts. @RISK allowed for the modeling of uncertainties associated with crop yield and price. Table 7 below reflects the statistics related to selected crops evaluated in this analysis.

Table 7
Statistical Evaluation of Selected Crops using @Risk
Based on Five Year Gross Income
Sacramento County

Selected Crop Type	Minimum	Maximum	Mean	Standard Deviation
Alfalfa Hay	$519	$1,142	$816	132
Almonds*	$895	$2750	$1,899	394
Corn Grain	$475	$827	$656	82
Rice	$980	$2,049	$1,481	230
Tomatoes	$1,647	$2,892	$2,247	283
Small Grain – Wheat	$188	$454	$324	61
Walnuts*	$2,318	$3,297	$2,799	235
Wine Grapes*	$2,805	$3,824	$3,304	220

Statistical Evaluation of Selected Crops using @Risk
Based on Three Year Gross Income
Sutter County

Selected Crop Type	Minimum	Maximum	Mean	Standard Deviation
Alfalfa Hay	$916	$1,392	$1,137	104
Almonds*	$895	$2750	$1,899	394
Corn Grain	$817	$935	$885	27
Rice	$1,237	$2,217	$1,737	220
Tomatoes	$2,470	$2,891	$2,696	94
Small Grain – Wheat	$439	$508	$479	16
Walnuts*	$2,318	$3,297	$2,799	235
Wine Grapes*	$2,805	$3,824	$3,304	220

*Due to lack of information data for in Sutter County Almond and Walnut yields and prices was used for Sacramento County analysis. Wine Grape data reported in Sacramento County was used for Sutter County.

Table 8 illustrates the estimated per acre crop loss by respective county. The results are based on multiplying the direct production costs and the value of crop at risk for each month times the monthly probability provides the probable damages expected if a flood event occurred in any particular month. Uncertainty parameters were used in the overall computation of both direct production losses and the net incomes for each crop impacted.

Table 8
Statistical Losses of Selected Crops using @Risk
Based on Direct Production Costs, Net Income at Risk and Probability of Flooding
Sacramento County

	Three Day Duration Period			Forty Five Day Duration Period		
Crop	Expected Value	Mean Value	Standard Deviation	Expected Value	Mean Value	Standard Deviation
Alfalfa Hay	$291	$299	38	$664	$671	43
Almonds*	$804	$887	117	$7,900	$7,977	126
Corn Grain	$272	$280	37	$272	$279	38
Rice	$320	$311	56	$395	$383	93
Tomatoes	$1,003	$1,033	259	$1,351	$1,328	285
Small Grain – Wheat	$393	$389	47	$393	$389	48
Walnuts*	$714	$780	106	$7,810	$7,882	109
Wine Grapes*	$2,026	$2,044	370	$8,593	$8,634	303

Statistical Losses of Selected Crops using @Risk
Based on Direct Production Costs, Net Income at Risk and Probability of Flooding
Sutter County

	Three Day Duration Period			Forty Five Day Duration Period		
Crop	Expected Value	Mean Value	Standard Deviation	Expected Value	Mean Value	Standard Deviation
Alfalfa Hay	$357	$369	57	$775	$790	100
Almonds*	$815	$823	132	$7,900	$7,978	128
Corn Grain	$262	$287	33	$262	$285	37
Rice	$382	$420	69	$519	$574	120
Tomatoes	$1,090	$1,220	264	$1,387	$1,594	289
Small Grain – Wheat	$364	$393	44	$364	$394	48
Walnuts*	$747	$815	134	$7,870	$7,912	187
Wine Grapes*	$2,054	$2,144	412	$8,632	$8,687	382

Table 9 provides a summary of the total damages by flood event for the assumed non-eroded levee's that would typify the "with project" condition of the Sacramento River Bank Protection Project. These numbers will be incorporated into the HEC-FDA model for computation of the annualized flood damages which are used in deriving the benefits associated with repair of erosion sites within the project overall methodology.

Table 9
Agricultural Damages by Flood Event
With No Levee Erosion Damage

Total Estimated Dollars of Damages by Event*

	---------------------- Flood Frequency --------------------------					
TOTAL FOR STUDY AREA						
CROP LOSS	5	10	50	100	200	500
FRUITS AND NUTS	0	34,242,743	130,854,945	163,851,850	210,573,661	237,732,014
FIELD CROPS	0	6,127,676	38,337,679	45,566,161	53,827,819	57,326,553
PASTURE & ALFALFA	0	2,836,073	13,241,504	15,066,674	19,808,067	21,704,736
RICE	0	33,035,093	63,127,396	70,519,708	88,532,509	96,772,059
TRUCK CROPS	0	3,279,717	65,516,449	77,942,366	82,974,186	89,463,638
VINE CROPS	0	0	0	0	0	0
OTHER	0	330,014	810,272	939,552	1,569,280	1,777,104
TOTAL	0	79,851,316	311,888,244	373,886,311	457,285,522	504,776,104

ENCLOSURE 6

Frequency-Damage Curves: Urban

Sacramento River Bank Protection Project
Frequency-Damage Curves (Urban) by Economic Impact Area
October 2012 Price Level
In $1,000s

Economic Impact Area	Damages by Frequency Event						
	2-Year	10-Year	25-Year	50-Year	100-Year	200-Year	500-Year
Butte Basin (5)	0	0	0	0	0	0	0
Grimes (10)	0	0	0	64	67	360	725
South Sutter (11/34)	0	0	0	2,856	3,078	3,142	3,557
Knight's Landing (13/14)	0	0	0	29,066	29,848	31,174	38,540
Yolo (15)	0	0	0	0	0	0	0
Woodland (16)	0	0	0	0	0	0	0
Davis (17)	0	0	0	0	3,746	5,963	17,281
Linda (27)	0	0	0	1,927	2,619	5,227	7,340
Rio Oso (30)	0	0	0	7,265	7,302	7,419	7,855
North Sutter (32)	0	0	0	0	6,341	7,044	7,432
Elkhorn (35)	0	0	0	0	0	0	0
Natomas (36)	3,766,252	4,342,314	4,439,523	4,569,310	4,620,389	4,669,933	4,690,256
Arden (37)	0	0	0	0	0	4,243,267	4,761,432
West Sac (38)	1,166,333	2,245,241	2,595,729	2,814,315	3,419,238	3,574,309	3,661,753
SouthPort (39)	921,685	1,343,451	2,170,619	2,683,658	3,270,179	3,400,424	3,462,783
Sacramento (40)	27,106	27,106	27,106	55,473	58,984	9,279,294	13,745,279
Clarksburg (42)	0	0	0	0	0	0	2,922
Merritt island (46)	0	0	0	7,092	8,791	12,118	14,793
Sutter Island (49)	0	0	0	757	762	762	777
Grand Island (50)	0	0	0	0	0	0	0
Tyler Island (53)	306	306	306	306	306	306	306
Brannan Andrus Island (54)	0	0	0	25,987	26,127	26,418	27,732
Ryer Island (55)	0	0	0	74	74	74	90
Hastings Tract (61)	0	0	0	0	0	0	0